



**forum for
the future**

Open Eco Rating (V3)

A User Guide

September 2015

About Forum for the Future

Forum for the Future is a sustainability non-profit that works globally with business, government and others to solve tricky challenges.

We aim to transform the critical systems that we all depend on, such as food and energy, to make them fit for the challenges of the 21st century. We have 19 years' experience inspiring new thinking, building creative partnerships and developing practical innovations to change our world. We share what we learn from our work so that others can become more sustainable.

System innovation is at the heart of our strategy. One of our key approaches is creating innovation coalitions, bringing together groups to solve bigger sustainability challenges - including those that work across whole value chains. Another of our approaches is helping pioneering businesses go further, faster.

Discover our stories and what we've learned about building a sustainable world at www.forumforthefuture.org, or follow us on [Twitter](#) or [Facebook](#).

Contents

1	Introduction	5
2	The purpose of the scheme	6
2.1	Background	6
2.2	Key principles	7
2.3	The history of eco ratings	8
2.3.1	Vodafone	8
2.3.2	Telefónica	8
2.3.3	GSM Association	8
2.3.4	International Telecommunication Union (ITU)	10
2.3.5	Orange	12
3	Methodology overview	13
3.1	Modules	13
a)	Corporate score	13
b)	Life Cycle Assessment (LCA) score	13
c)	Responsible design score	14
d)	Functionality moderator	14
3.2	Overall score	15
3.2.1	Absolute and normalised scores	16
3.2.2	Data sources for the calculation	16
3.3	Global warming potential calculation	17
3.3.1	CO ₂ manufacturing	17
3.3.2	CO ₂ transportation	18
3.3.3	CO ₂ use phase	19
3.3.4	CO ₂ end of life	19
3.4	Raw material depletion (RMD) calculation	20
3.5	How to use the tool	22
3.6	The future of the scheme	22
4	Thanks	22
5	What would we like from you?	23
6	Completing the questionnaire	24
6.1	Introduction	24
6.2	Overview sheet	24
6.3	LCA basics sheet	24
6.3.1	General tips and recommendations:	24
6.4	LCA basics questions	26
6.4.1	Screen manufacturing emissions	26

6.4.2	Printed Circuits Board (PCB) manufacturing emissions.....	27
6.4.3	Electronic components manufacturing emissions.....	29
6.4.4	Camera manufacturing emissions	31
6.4.5	Rest of device manufacturing emissions.....	33
6.4.6	Transportation emissions.....	36
6.4.7	Use phase emissions.....	37
6.4.8	End of life emissions	39
6.4.9	Raw material depletion impacts	39
6.5	Responsible design sheet	44
6.5.1	Product durability, repairability and serviceability	44
6.5.2	Power conservation	46
6.5.3	Sustainable materials.....	49
6.5.4	Packaging and logistics efficiency	55
6.5.5	Disposable impacts.....	59
6.5.6	Functionality	59
7	Appendices	61
7.1	Appendix 1: Default values	61
7.1.1	Table 1: Default values	61
7.2	Appendix 2: Secondary data sources (models and assumptions)	65
7.2.1	Table 1: Semi-specific data.....	65
7.2.2	Table 2: Secondary data.....	65
7.3	Appendix 3: Modelling GHG emissions for the manufacturing of electronic components, based on the silicon surface area	67
7.4	Appendix 4: Modelling the charger, casings, rest of the device and packaging.....	72
7.4.1	Modelling the charger	72
7.4.2	Modelling the casing	74
7.4.3	Modelling the rest of the device	74
7.4.4	Modelling packaging and documentation.....	75

1 Introduction

Welcome to the third version of Eco Rating – a tool that harmonises the environmental mobile phone rating methodologies of Vodafone, Telefónica and Orange in order to create a more standardised and simplified way of assessing the environmental credentials of mobile phones. It has been developed in collaboration with device manufacturers that supply to these three global networks.

One of the biggest changes in comparison to Eco Rating 2.0 is that this version includes an open Life Cycle Assessment (LCA). This means that the tool calculates the life cycle impacts independently and does not rely on the calculations of a third party. The importance of this is that it gives the tool total transparency – a key principle of our approach – and enables users to see the impact of devices, and changes to those devices, in real time.

We have also added some new questions to the assessment, and removed redundant ones, to keep the tool up to date with changes in technology and ensure it continues to push for further improvements to drive greater change across the sector.

Open Eco Rating (V3) takes a significant step towards a more harmonised market standard for product ratings and, with the open LCA, is more transparent than previous versions or other assessments on offer. In the future, we hope to engage more network operators and manufacturers to use the tool so that the task of reporting mobile phone impacts is even easier and more robust, and consumers are even better positioned to make informed purchase decisions.

2 The purpose of the scheme

2.1 Background

Consumers increasingly want to know the sustainability credentials of their purchases. This extends to the electronic mobile devices that they use – not least because of the strong personal connection to them.

Mobile phone manufacturers have reported sustainability credentials of their devices for a while – some for a very long time – but the lack of comparability between approaches has prevented consumers from clearly comparing one device against another. More recently, mobile network operators have developed eco rating schemes that allow standardised comparison of handsets.

However, while devices within network line-ups are now comparable, their ratings can't be compared to devices on other networks because each rating has been developed independently. Given that these schemes have been developed (in part) to reduce consumer confusion, it's important to ensure that network operators don't undermine this by contradicting one another. It's also a waste of time for network operators to be chasing similar data from manufacturers, and an enormous waste of resources for manufacturers to provide it many times over.

Work by both the GSM Association (GSMA) and the International Telecommunications Union (ITU) demonstrate that there are strong alignments between the goals of the various assessment schemes, and the basic elements that go into them. For instance, the majority of assessments include a core set of questions that examine the basics of manufacturing and using a device. Similarly, most also ask questions about the wider sustainability of a device, such as what substances it is made from, what packaging it comes in and how it has been designed for longevity. The overlaps are not perfect, but there is enough commonality to make harmonising both possible and desirable.

Open Eco Rating (V3) combines the best elements of several network rating systems, and was developed using feedback from manufacturers and network operators across the industry. It replaces the eco ratings used by Telefónica O2, Vodafone and Orange and has been adopted by a number of other network operators around the globe – so these networks can now share a common eco rating across all mobile devices they offer. It is also a core part of the ITU's draft eco rating scheme.

2.2 Key principles

Open Eco Rating (V3) is based on a number of key principles:

Accuracy – it must give the right answer. It has been tested with many device manufacturers to ensure that its results are in line with their own in-house assessments and also fits with their understanding of where their devices sit relative to those of their competitors.

Simplicity – it must be easy to complete the assessment in order to get people to do so. All the questions either ask for a simple number, a yes/no answer, or selecting one of a few basic options. There are no open-ended questions which could be open to interpretation. Once a manufacturer is familiar with the tool, it can be completed in as little as 30 minutes.

Completeness – it must ask all the questions that are relevant to understanding the total sustainability of a device. It doesn't just look at part of the picture. This completeness means that it is compatible with most, if not all, other schemes out there. It will provide the total Eco Rating score, but if a network only wants to use a sub-set of the questions or issues then these results can also be extracted.

Transparency – it must be self-contained so that no third-party can change the conditions of use of the tool and so the results of the assessment are presented within the tool as soon as all of the questions have been answered. This is essential for driving innovation and change because it allows a user to precisely understand how changing each element of the device will improve, or reduce, its sustainability score.

Comparability – it has to enable devices from different manufacturers to be compared in a robust way. To do this, it doesn't ask for information that is open to interpretation between manufacturers, or which requires detailed life cycle data that will vary depending on the assumptions and knowledge of the assessor.

Equitability – it has to be fair to all manufacturers and not artificially reward or penalise one over another. The tool has widespread support from the manufacturer community not only because it simplifies the number of data requests that they get, but because it gives fair results.

Relevance – it has to ask questions that are meaningful and add to the strength of the tool. It is very easy to make something complicated, but complicated to make something easy, so the temptation can be to add in more and more simply because it can be easily measured. We have done the opposite, finding ways to assess things that are traditionally difficult because they are relevant to the total sustainability, and taking out lots of things that have little genuine importance and impact.

2.3 The history of eco ratings

2.3.1 **Vodafone**

The Vodafone eco rating is a self-assessment tool where manufacturers are asked to answer a wide range of questions in order to assess the environmental and social impact of the phone throughout its life cycle. It was created and launched in 2011 and has since been rolled out to more than a dozen countries. It was developed with the support of expert agencies Bureau Veritas CODDE and SKM Enviros. Upon launch of the first version it received limited assurance by KPMG Sustainability Services. Since then it has gone through multiple iterations of improvement based on input of stakeholder dialogues.

From the start of its eco rating program, Vodafone has supported the ambition of one methodology for the whole handset industry, which would provide more clarity to the customer and reduce the administrative burden on suppliers. The company has been actively contributing to industry standardisation initiatives such as the working groups in the GSMA and ITU-T. For the development of Open Eco Rating (V3), Vodafone has granted access to all of its eco rating intellectual property and learnings.

2.3.2 **Telefónica**

Telefónica's Eco Rating was launched in 2010 following a year of consultation with industry experts and device manufacturers. Creation of the tool was coordinated by Forum for the Future (Forum), using detailed life cycle assessment data and principles, coupled with manufacturer information and insights, to develop a self-assessment tool that addresses full sustainability impacts of a device. It has been used by Telefónica to communicate with consumers in a number of countries, and also to inform handset sustainability thinking at group level.

As with Vodafone, Telefónica has been a champion of a unified industry approach for many years and continues to contribute its energy and expertise to industry working groups in order to achieve this end. All of its IP is likewise invested in Open Eco Rating (V3), which the company uses to assess the sustainability of all handsets in many of its operating markets.

2.3.3 **GSMA Association**

The GSMA produced a study in February 2012 that first explored the opportunities and challenges of a unified eco rating scheme. It had the full support of the organisations that had detailed and active eco rating schemes at

the time – Deutsche Telekom, Orange France, SFR, Telefónica O2 and Vodafone, as well as OEM participation from a number of manufacturers.

The results of that study found that while none of the schemes were identical, there were many similarities between the five tools, and they all shared a set of common principles at their heart. The main differences came from the breadth of their sustainability scope, and the degree to which they look to drive innovation – as summarised in the table below. Note that these results related to the tools as they were in 2011 and that all have evolved since then, often in even more complimentary directions.

Sustainability Issue:	Deutsche Telekom	Orange	SFR	Telefónica O2	Vodafone
Carbon footprint	X				
Raw materials and manufacturing proxies		X	X	X	X
Transportation distances and modes		X	X		X
Use impacts		X	X	X	X
Transportation efficiency				X	
Resources					
Raw materials and manufacturing proxies	X	X	X	X	X
Water footprint					
Raw materials and manufacturing proxies	X	X	X	X	X
Sustainable design	X				
Conflict minerals	X	X		X	X
Hazardous materials	X	X		X	X
Packaging	X	X		X	X
Charger efficiency			X	X	X
Energy saving	X	X		X	X
Longevity (of device and/or peripherals)	X	X		X	X
Waste reduction	X	X		X	
Exposure to radiation	X				
Corporate sustainability / supply chain	X				
Sustainable management systems	X			X	X
Resource management policies				X	X
E-TASC adoption	X				X
Sustainability reporting				X	X
Social inclusion	X			X	
Functionality - Enabling sustainable lifestyles	X			X	
Sustainability of service offering	X				

Source: Forum for the Future (2012). GSMA review of network eco ratings

Following this initial study and discussion by the GSMA working group, a full project was initiated to develop a harmonised eco rating tool. The specification

for this was well developed when it was decided to combine the GSMA work with that of the ITU. Nevertheless, the lessons and industry feedback developed through that process set up the collaborations that have resulted in Open Eco Rating (V3), and have contributed to its development.

2.3.4 International Telecommunication Union (ITU)

The ITU also launched an assessment of eco rating schemes with a view to understanding the opportunities for harmonisation. It was published in September 2012, and despite categorising the issues slightly differently and including a wider set of eco rating schemes that had launched more recently, it also found that there were good opportunities for developing a unified solution that better met the needs of all – consumers, networks and manufacturers alike:

Eco-rating includes information on:	AT&T	Orange/France Telecom	Telefónica	Sprint	UL	Vodafone
Company Performance						
GHG Emissions	✓		✓	✓	✓	✓
Environmental Management	✓		✓	✓	✓	✓
Health and Safety			✓	✓	✓	✓
Labour Management			✓			✓
Ethical Business Principles			✓			✓
Corporate Sustainability	✓		✓	✓	✓	✓
Supply Chain Performance						
GHG Emissions		✓				✓
Environmental Management			✓	✓	✓	✓
Health and Safety			✓	✓	✓	✓
Supplier Code			✓	✓	✓	✓
Labour Management			✓	✓	✓	✓
Ethical Business Principles			✓			✓
Conflict Minerals		✓	✓	✓	✓	✓
Supply Chain Auditing			✓			✓
Handset						
GHG Emissions		✓				
Material Usage	✓	✓	✓	✓	✓	✓
Hazardous Materials	✓	✓	✓	✓	✓	✓
Packaging	✓	✓	✓	✓	✓	✓
Energy Efficiency	✓	✓	✓	✓	✓	✓
Innovation			✓	✓	✓	
Recycling and Device Life	✓	✓	✓	✓	✓	✓
Other						
External Consultation		✓	✓	✓	✓	✓
Audit and Verification			✓	✓	✓	✓

Source: ITU-T (2012). Review of mobile handset eco rating schemes

This work, and that of the GSMA before it, subsequently led to the creation of the ITU-T Working Group 5 on standardisation of global eco ratings, which is in the process of developing a harmonised sustainability standard. The political and logistical complexities of engaging a very wide group of stakeholders means this work is still ongoing, but in order to provide the group with something tangible, rather than theoretical, to help it make decisions we created the first iteration of Open Eco Rating (V3), with the support of Telefónica and Vodafone.

Open Eco Rating (V3) continues to form the core of the developing ITU approach, and has benefited from detailed feedback and recommendations by the many international stakeholders in the ITU-T working group.

2.3.5 Orange

The Orange scheme was the first eco rating on the market, being launched in France in 2008 before being rolled out to Spain, Poland, Romania and Armenia. As with the other schemes, it has undergone continuous development since that time – particularly in the streamlining of questions to get to the heart of the sustainability issues in the simplest ways. It was developed with co-operation from external stakeholders, in particular WWF France, who continue to help revise the methodology each year to keep it up-to-date and remove unnecessary complexity.

Orange has been a supporter of a harmonised approach for many years, and was as active participant in the work of the GSMA and the ITU. In early 2015, Orange decided to join Forum's Eco Rating in order to drive the synchronisation of rating tools in the market further. Its participation, in collaboration with O2 UK and Vodafone, allowed this harmonised version of the tool to be created with the open LCA.

3 Methodology overview

The answers to around 100 questions about the environmental and social impact of each phone are combined to give an overall rating or score. The Eco Rating score ranges from zero to five, with five representing the most sustainable score possible, and is typically displayed alongside the mobile phone.

3.1 Modules

The overall score is generated out of four modules: a) corporate score, b) LCA score, c) responsible design score, and d) functionality score.

	Absolute scores	Normalised scores	Weighting
a) Corporate score	89 / 100	8.9 / 10	30%
b) LCA score	8.2 / 20	4.1 / 10	30%
- Global warming	0 / 10	0 / 10	15%
- Raw material depletion	8.2 / 10	8.2 / 10	15%
c) Responsible design score	47 / 99	4.8 / 10	40%
- Product durability & life extension	16 / 32	5 / 10	13%
- Power conservation	6 / 10	6 / 10	10%
- Sustainable materials	12 / 36	3.3 / 10	7%
- Packaging and logistics efficiency	13 / 19	6.9 / 10	3%
- Disposal impacts	0 / 2	0 / 10	3%
d) Functionality moderator	6 / 6	6 / 6	N/A

a) Corporate score

Since it would be inappropriate and misleading to assess a device without also looking at the performance of the manufacturer, Open Eco Rating (V3) also assesses how committed the maker is to managing the environmental and social issues it faces and how it manages its supply chain. This is done through the use of recommended industry standards, in particular ETASC by Ecovadis. The questions evaluate the standards, policies and procedures that the manufacturer has in place and rewards manufacturers that go beyond legal requirements.

If you'd like to know more about the corporate or social criteria covered in the Ecovadis methodology, please contact: support.ecovadis.com.

b) Life Cycle Assessment (LCA) score

The LCA is based on the life cycle assessment guidelines specified in the ISO 14040:2006 and ISO 14044:2006 standards, as well as ILCD Handbook requirements. However, instead of collecting the data in the tool and then requesting the assessment from a third party, we have built the life cycle assessment calculation into the tool directly so that it provides the CO₂ emission impacts and the raw material depletion impact automatically. It also shows the

user precisely how and where these figures were calculated – and so where changes could be made to improve them.

The LCA methodology used in Open Eco Rating (V3) allows the comparison of mobile phones according to two environmental indicators:

- 1) **Global warming (GW):** this indicator calculates the contribution to the warming of the atmosphere through the release of specific gases. It is expressed in kilograms of CO₂, using an equivalent for the warming potential of other gases based on the Intergovernmental Panel on Climate Change's methodology (IPCC, US, 2007).
- 2) **Raw material depletion (RMD):** This indicator calculates the depletion of natural resources. It is taking into account the size of the resource reserves that meet specified minimum physical and chemical criteria related to current mining practice and the consumption rate of 2000's economy. It is expressed in grams of Sb (antimony), as if all resources were Sb, using their depletion potential. The methodology used is the CML2002, Van Oers et al. 2002, used within indicator set.

Note: The raw material depletion impact indicator is also known as abiotic resources depletion.

Impact data for both indicators is summarised in an additional box in the tool:

TOTAL CO2 impact (kg CO ₂ e):	86.45
TOTAL RMD impact (g Sb e):	1.79

c) Responsible design score

Manufacturers are asked to answer a wide range of questions in order to assess the environmental and social sustainability of the phone throughout its life cycle – much of which is down to the design of the device and its associated materials. These questions include information on the extraction of raw materials and the production of the components used in the phone, the substances of concern in the device, and the efficiency of its packaging and transport. The impact of using the phone and its disposal depend partially on customers' behaviour, but both of these can be positively influenced by the design of the phone and are assessed as well. We also assess the sustainability benefits of the phone in the way that it helps customers lead more sustainable lives.

d) Functionality moderator

The sustainability impact of a mobile phone is not just in how it is made and what comes out of the box, but also in how it is used and what sustainable changes it

enables in the user's life. Arguably, this 'indirect' sustainability impact is far greater than the 'direct' impact, and its consideration also allows different types of phones to be fairly assessed alongside each other.

A smartphone, for instance, will almost always have a far greater direct sustainability impact than a simple feature phone, simply because its size and complexity means it has far greater raw material and power consumption impacts. However, this added complexity also brings added indirect sustainability benefits, which the feature phone may not have.

One set of additional benefits is covered by the questions in the functionality moderator, which look at the ability of the device to replace the need for other ones. This convergence of different devices in one package means that phones are increasingly replacing the need for a host of other devices, which a consumer might previously want.

We do not assume that all of the devices listed will actually be replaced by each user, but we do believe that if a function is needed by the user, then they are less likely to buy an additional device to provide it if they have it in their mobile phone already. The inclusion of GPS and satellite navigation capabilities in mobile phones, for example, caused a crisis in the sales and share price of previous in-car navigation devices. Similarly, the way we share media means that the market for small digital cameras has collapsed now that the quality and improved sharing functionality is built into mobile phones.

3.2 Overall score

Open Eco Rating (V3)

[A collaborative initiative from Forum for the Future](#)

Product manufacturer		Date of assessment		Overall score 3.2 / 5
Product model no. / name		Name of assessor		
Brief description of mobile phone				

Eco Vadis Corporate Score (please enter a value from 1 to 100)

89

	Absolute scores	Normalised scores	Weighting
Corporate score	89 / 100	8.9 / 10	30%
LCA score	8.2 / 20	4.1 / 10	30%
- Global warming	0 / 10	0 / 10	15%
- Raw material depletion	8.2 / 10	8.2 / 10	15%
Responsible design score	47 / 99	4.8 / 10	40%
- Product durability & life extension	16 / 32	5 / 10	13%
- Power conservation	6 / 10	6 / 10	7%
- Sustainable materials	12 / 36	3.3 / 10	10%
- Packaging and logistics efficiency	13 / 19	6.9 / 10	7%
- Disposal impacts	0 / 2	0 / 10	3%
Functionality moderator	6 / 6	6 / 6	N/A

The overall Eco Rating score is formed of the Corporate, LCA and Responsible design scores, weighted accordingly. In addition, points for sustainable functionality are added as well – with each functionality point being worth 0.05 Eco Rating points. There are currently a maximum of six possible functionality points, which could add up to 0.3 points to the final Eco Rating score.

The calculation follows:

Overall score (0.0 - 5.0, with maximum/best score of 5.0) =
Global warming potential (out of 10) × 15% + **Raw material depletion**
(out of 10) × 15% + **Responsible design** (out of 10) × 40% + **moderator**

Note: In Eco Rating 2.0 we used an additional indicator for water depletion; however, since the water depletion figures were generated from the same data as the CO₂ figures, they were strongly correlated and had no differentiating impact on the final score. For the latest version we decided, in consensus with the current users, to remove this indicator for simplicity.

3.2.1 Absolute and normalised scores

The absolute scores show the results for each section of the tool – giving the actual number of points scored in each section out of the total number of points available. While interesting, this information is hard to compare across categories of impact, so normalised scores are also given which convert this raw data into a uniform 10-point scale for each impact section. The weightings for each section can then be applied to these normalised scores to more easily calculate the total Eco Rating score.

3.2.2 Data sources for the calculation

a) Primary data

The data for the calculation is taken from the answers provided by the users of the tool as they complete the questionnaire. Because we need to provide a final score on a finite scale (i.e. from 0 to 5), we need to be able to set the upper and lower limits for questions in order to be able to see where a device falls between those two extremes. This relative scoring approach is the same as with all other assessments that need to place devices on a finite scale, which allows simple comparison. For most of the questions this is easy to do because they are binary or already on a defined scale (one point for answer x, two points for y, or three points for z). However, for some of the life cycle questions where we ask about area of components we need to set the minimum and maximum values based on empirical evidence taken from devices in the market.

All questions need an answer in order to provide a final score. In most cases we require the user to give the data needed, but in a few cases we recognise that this may not always be possible – particularly for device manufacturers that are at the beginning of the eco rating process, or who have a less-strong relationship

with their supply chain. In these cases we allow the user to say they don't have the information and instead apply a punitive default value, which gives the lowest possible score for that question.

Find an overview of the default value we used in Table 1 of Appendix 1.

b) Secondary data

In order to calculate environmental impacts we sometimes need to use assumptions and models. Appendix 2 lists the data sources we used for some impact calculations.

3.3 Global warming potential calculation

This is measured in kilograms of CO₂ equivalent and is given in both total kg of CO₂ (in the LCA sheet) and as a relative score out of 10 (in the overview sheet) to enable the total Eco Rating score to be calculated. The overall global warming potential includes the calculations from manufacturing, transport, use and end of life emissions, which are outlined below.

The calculation for the global warming potential is as follows:

Global warming potential calculation = CO₂ manufacturing + CO₂ transportation + CO₂ use + CO₂ end of life

3.3.1 CO₂ manufacturing

Emissions included in the overall manufacturing emissions value come from the manufacture of:

- Screen
- Printed circuit board (PCB)
- Electronic components
- Camera
- Rest of device

The calculation for the manufacturing emissions is as follows:

$$\begin{aligned} \text{CO}_{2m} = & \text{CO}_{2\text{LCD}} \times \text{SLSC} + \text{CO}_{2\text{rigid}}(n) \times \text{S}_{\text{MainPCB}} + \text{CO}_{2\text{rigid}}(4) \times \sum \text{S}_{\text{rigid}} + \\ & \text{CO}_{2\text{flex}} \times \sum \text{S}_{\text{flex}} + \text{CO}_{2\text{components}}(\text{S}_{\text{Si}}) + \text{CO}_{2\text{battery}} \times \text{m}_{\text{battery}} + \text{CO}_{2\text{charger}} \\ & (\text{m}_{\text{charger}}) + \sum \text{CO}_{2\text{casing}}(i) \times \text{m}_{\text{casing}}(i) + \text{CO}_{2\text{rest}} \times \text{m}_{\text{device}} + \text{CO}_{2\text{pack.}} \times \text{m}_{\text{pack.}} + \\ & \sum \text{m}_i \times \text{d}_{\text{plane}} \times \text{CO}_{2\text{plane}} \end{aligned}$$

S_{LCD} :	Total area of screens, in cm^2
$S_{MainPCB}$:	Main PCB area, in cm^2
ΣS_{rigid} :	Total surface of rigid PCB (LCD, keypad, touch panel key and others), in cm^2
ΣS_{flex} :	Total area of flex PCB, in cm^2
S_{Si} :	Total area of silicon die/chip in integrated circuits with more than 12 connections, in cm^2
$m_{battery}$:	Battery weight, in g
$m_{charger}$:	Charger weight, in g
$m_{casing(i)}$:	Weight of material i in the casing, in g
m_{device} :	Weight of the device in g
m_{pack} :	Packaging and documentation weight in g
$d_{i,plane}$:	Distance covered by plane to the customisation site of the component i

3.3.2 CO₂ transportation

Questions relating to the geographical location of manufacture aim at modelling the distribution of the handset from the factory to the distributor warehouse. Given that most devices are transported by air, this is set as the default travel option, but it can be changed by users to other methods.

We have reduced the number of transport questions to simplify the assessment and enable a single score to be calculated for a device which can then be used across European markets. This is important for maintaining comparability and simplicity, and is appropriate since the relative contribution of transport emissions to the total CO₂ impact is small, and the marginal difference in distance between our default European location (Paris) and other destinations is smaller. Similarly, we assume a single representative location for originating markets on each manufacturing continent (e.g. Shenzhen for Asia).

The calculation for the transportation emissions follows:

$$CO_{2distribution} = m_{product} \times (CO_{plane} \times d_{plane} + CO_{truck} \times d_{truck} + CO_{ship} \times d_{ship} + CO_{2train} \times d_{train})$$

$m_{product}$: Mass of the product and its packaging in g

d_{plane} ; d_{truck} ; d_{ship} ; d_{train} : Transportation distances, by mode of transport

CO_{2plane} ; CO_{2truck} ; CO_{2ship} ; CO_{2train} : Transportation emission factors (see secondary data)

3.3.3 CO₂ use phase

We calculate the use phase emissions with the following formula:

Lifetime CO₂ = energy to charge battery ((capacity of battery (mAh) x voltage (V))/1000) x charger efficiency (65%) x number of charges per year x years of use x CO₂ impact (kg CO₂/kWh).

This is another simplification in order to use absolute values that we can check and verify (voltage and battery capacity), rather than theoretical indicators that we can't (e.g. stated talk time). We assume a charging efficiency rate of 65% based on research by network partners and available publications¹.

Other assumptions are the number of charges – we have assumed a daily charge for a smartphone and a charge every other day for feature phones. In practice this will vary from user to user depending on their mobile phone usage patterns, but is, for now, a fair (inasmuch as it is equally fair or unfair to all, and so won't unduly reward or penalise any manufacturers) assumption of average user patterns. If anything, it is likely to slightly overestimate total actual CO₂ impacts, which is preferable to underestimating them.

As with other parts of the LCA, we take France as the European proxy and so use the French grid energy mix to give us the CO₂ impact per kilowatt hour. This is partly to keep the assessment consistent, but also to enable Eco Rating to comply with French legislation requiring the CO₂ impact of devices.

3.3.4 CO₂ end of life

This formula is used to calculate end of life emissions:

¹ E.g. "An Energy-Aware Survey of Mobile Phone Chargers" – GeSI - 2011

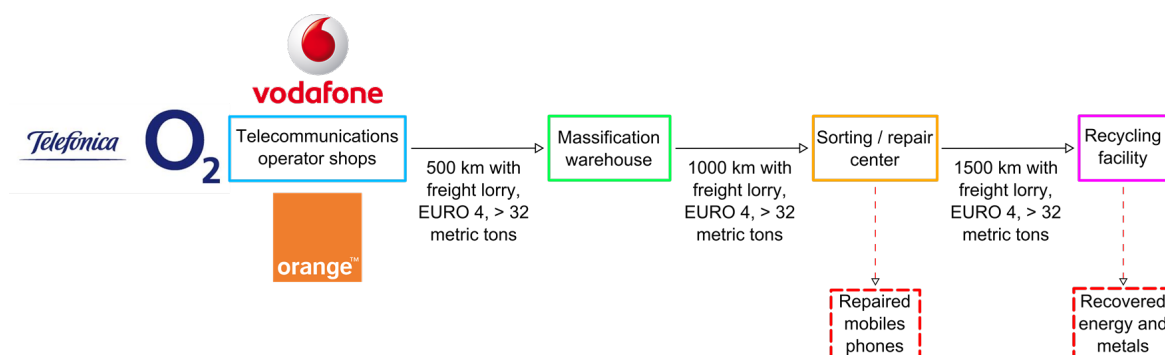
² Abiotic resources depletion review for mobiles phones – Orange – 2015 (VAIJA, GARCIA, RICCI) – contact for further information: samuli.vaija@orange.com

$$\text{Mass of mobile (g)} \times 3000 \times 0.00011 + \text{mass of mobile (g)} \times 0.321 + \text{mass of battery (g)} \times 1.88 + (\text{mass of mobile} - \text{mass of battery}) \times 0.465$$

We assume that mobile phones are shipped:

- from shops to a warehouse (distance assumption: 500 km);
- from warehouse to sorting centre, where some of them are repaired and sold on second-hand markets (distance assumption: 1000 km);
- from sorting centre to recycling facility, such as Umicore in Belgium or Boliden in Sweden, where precious metals (e.g. silver, gold, platinum, palladium), special metals (e.g. indium), secondary metals (e.g. antimony, tin, bismuth) and base metals (copper, nickel) are recovered (distance assumption: 1500 km).

The figure below displays the different steps:



Only those devices that are dismantled and sent to material or energy recovery are considered; the second-hand markets are considered out of the scope of the evaluation (red dash line box in the figure above).

Benefits from recycling or energy recovery are not accounted for in this scenario (due to a lack of reliable data), which only takes into account direct impact from transportation and treatment processes (red dash line box in the figure above).

LCA models for transport, sorting, battery and mobile phone treatment in a copper smelter for metals recovery were picked in Ecoinvent 3.0 database.

3.4 Raw material depletion (RMD) calculation

$$\text{Weight of gold (mg) in device} \times \text{weight of silver (mg) in device} \times \text{weight of tin (mg) in device} \times \text{weight of tantalum (mg) in device} \times \text{abiotic depletion potential (g antimony equivalent)}$$

The RMD indicator is presented as both an absolute score in grams of antimony equivalent (in the LCA sheet) and as a relative score out of 10 (in the overview sheet).

Rare metals included in the calculation are:

- Gold
- Silver
- Tin
- Tantalum
- Indium

In order to pick the most critical resources, Orange carried out two extensive material content assessments² for a feature phone and a high-end smartphone. Materials declarations sheets (MDS) were used instead of generic LCA software models (see example of MDS above for a multi-layer Thin-film 0201 SMD inductor) to assess the quantities of 27 resources.

	Homogeneous Material	Weight	Unit of Measure		Level	Substance Category		Substance	CAS	Exempt	Weight	Unit of Measure
+M -M	Substrate	0.065	mg	▼	+C -C Supplier ▼	Aluminum Oxide	+S -S	Al2O3	1344-28-1	▼	0.065	mg ▼
+M -M	Cover	0.052	mg	▼	+C -C Supplier ▼		+S -S	Al2O3	1344-28-1	▼	0.052	mg ▼
+M -M	Dielectric	0.002	mg	▼	+C -C Supplier ▼	Silicon Oxynitride	+S -S	SiNO	112945-52-2	▼	0.002	mg ▼
+M -M	Element	0	mg	▼	+C -C Supplier ▼	Tantalum	+S -S	Ta	7440-25-7	▼	0.061	mg ▼
+M -M	Element	0	mg	▼	+C -C Supplier ▼	Silicon Dioxide	+S -S	Cr	7440-47-3	▼	0.002	mg ▼
+M -M	Element	0.006	mg	▼	+C -C Supplier ▼	Copper	+S -S	Cu	7440-50-8	▼	0.002	mg ▼
+M -M	Polyimide	0.001	mg	▼	+C -C Supplier ▼	Solvent	+S -S	N-methyl-pyrrolidone	872-50-4	▼	0	mg ▼
					+C -C Supplier ▼	Polymer	+S -S	Polyimide	109-17-1	▼	0.001	mg ▼
+M -M	Epoxy	0.001	mg	▼	+C -C Supplier ▼	Resin	+S -S	Bisphenol F	28064-14-4	▼	0	mg ▼
					+C -C Supplier ▼	Hardner	+S -S	Imidazole	288-32-4	▼	0	mg ▼
+M -M	Termination	0.015	mg	▼	+C -C Supplier ▼	Chromium	+S -S	Cr	7440-47-3	▼	0	mg ▼
					+C -C Supplier ▼	Copper	+S -S	Cu	7440-50-8	▼	0.003	mg ▼
					+C -C Supplier ▼	Nickel	+S -S	Ni		▼	0.013	mg ▼
					+C -C Supplier ▼	Tin	+S -S	Sn	7440-31-5	▼	0.011	mg ▼

The CML2002 abiotic resource depletion method was then applied to the material content result obtained with the MDS. The results for the top five most important resources regarding abiotic resources depletion are displayed in the tables below.

² Abiotic resources depletion review for mobiles phones – Orange – 2015 (VAIJA, GARCIA, RICCI) – contact for further information: samuli.vaija@orange.com

High end smartphone		Feature phone	
Resource	Abiotic resources depletion - <i>Reserve base</i>	Resource	Abiotic resources depletion - <i>Reserve base</i>
Indium (In)	41,76 %	Indium (In)	31,67 %
Silver (Ag)	20,97 %	Silver (Ag)	28,87 %
Gold (Au)	18,06 %	Gold (Au)	17,26 %
Tantalum (Ta)	8,00 %	Tin (Sn)	7,25 %
Tin (Sn)	4,04 %	Palladium (Pd)	5,66 %

3.5 How to use the tool

Open Eco Rating (V3) is a simple, Excel-based tool. Manufacturers are asked to answer the questions and provide supporting evidence in order to gain a score for each mobile phone. Each user of the methodology should verify the submitted answers and request further information, if needed.

The tool will give each device an Eco Rating score, as well as a wealth of sub-information about different elements of the phone. How you use and communicate this information, both internally and externally, is up to you. It could simply form a part of your procurement process to help inform you of the sustainability of your portfolio, or you could choose to use it to communicate with customers as well – for instance by:

- Showing the Eco Rating score for each device at point of sale;
- Only highlighting devices with superior Eco Rating scores using thresholds which indicate bronze/silver/gold/platinum levels of performance;
- Communicating other issues of interest alongside the Eco Rating score – such as carbon footprint, recycled content, conflict mineral management, or any one of a number of other issues.

It is the responsibility of any company using Open Eco Rating (V3) to apply the process in the correct way, including maintaining the confidentiality of the data submitted by the supplier and the integrity of the scheme as a whole, as well as the communication of the device scores.

For more information and to discuss usage of the tool, or examples of how others are using the tool, email ecorating@forumforthefuture.org.

3.6 The future of the scheme

The assessment has widespread support from manufacturers and networks already. It has been developed in close collaboration with many stakeholders, and has been revised again following expert feedback from the ITU-T Working Group 5 on standardisation of global eco ratings. Forum is currently acting as the hub for on-going development, and will continue to collate feedback and development suggestions to strengthen the tool as technology and sustainability issues develop.

As more networks join the scheme, this document will help explain how the tool works, the rationale behind each question, and give guidance on the way the questions should be answered. As explained above, the tool is self-contained so there is no need or obligation for networks to do any more than use it as they wish. However, Forum will continue to act as a hub for on-going feedback and revisions – making any necessary changes and supplying the updated tool to all network users so that the standardisation goal of the scheme is maintained.

The scheme will be continually evaluated to ensure the questions are relevant and fair; the aim is to make the criteria tougher in time, in order to drive better performance and reflect progress in technology. Users of the Eco Rating tool are encouraged to suggest changes and improvements, which are then co-ordinated by Forum to manage version control of the tool. In addition, Forum will hold periodic stakeholder briefings to bring stakeholders and users together. Feedback and inquiries may be sent to ecorating@forumforthefuture.org.

4 Thanks

Our thanks go to the following organisations who have helped in the development of this tool or the previous ones that it has evolved from: Blackberry, Bureau Veritas CODDE, GSMA, HTC, Huawei, ITU-T Working Group 5, LG, Nokia, Orange, Samsung, SKM Enviros, Sony Mobile, Telefónica and Vodafone.

5 What would we like from you?

We want you to use the tool and help make it better over time by contributing your suggestions and expertise on the evolving sustainability issues in the sector. Some additional reasons for you to use it are:

It is free to use and always will be. The intellectual property is owned by a not-for-profit organisation whose primary charitable purpose will only be met by keeping the tool perpetually open and free to use by all.

It helps consumers make an informed choice by providing a consistent assessment for devices across networks and geographies. No-one actively wants mobile phones to be less sustainable, with the problems that brings in consumer boycotts, disrupted supply chains, rising costs of materials etc. All being equal, consumers would generally prefer a more sustainable device to a less sustainable one, but few are actively making sustainability a key part of their primary selection criteria. At the same time, they are expecting networks and manufacturers to take the lead for them in driving social and environmental best practice.

It simplifies complexity for manufacturers by reducing the number of different assessments that they need to complete. Many of the devices you range will already have been assessed by this tool for one of the many other networks that use it – so most of the data you need is available to you already. This tool, and the ones it has been developed from, has been used by manufacturers for four years and so there is already widespread understanding and expertise on how to use it.

It provides a robust platform for driving sustainable innovation across the entire sector. Driving change across a sector is faster when the sector is clear about where it needs to go. The more networks use the tool, the more the manufacturers have a clear direction to move in, with confidence that making sustainable changes will be rewarded in recognition and support.

6 Completing the questionnaire

6.1 Introduction

The tool is a self-contained Microsoft Excel workbook. Keeping it self-contained was important to ensure that no additional calculations or assessments by third parties were needed to give an Eco Rating score for a device. Without this ability it is harder for device manufacturers to understand the relative importance of one sustainability measure over another, or to understand how making changes to a device would affect its sustainability. Excel is not the most sophisticated programme to use, but it was chosen because of its simplicity and transparency, as well as its widespread use, which makes the tool accessible for all.

The questions in the tool cover a simple life cycle assessment of the device, as well as a broader set of questions that cover the wider sustainability of its impacts – in its longevity, material use, transport logistics, user impacts, and so on. Corporate sustainability and social aspects are also covered, since it would be misleading to report on the sustainability of a device without also considering the sustainability of the supply chain, social compliance and management practices that have created it. However, for industry standardisation we do not ask for a unique set of corporate information, but instead rely on using the corporate assessment scores generated by the Eco Vadis assessment.

Most of the questions in the tool are mandatory in order to generate an overall score. However, the Open Eco Rating (V3) version allows a few default values for certain LCA questions in case some data is missing. We list the default values in Table 1 of Appendix 1.

6.2 Overview sheet

This is the first sheet in the workbook and should be completed first. It asks for some basic information about the device under assessment and the assessor, and is also where the Eco Vadis corporate score is entered.

Having completed all of the questions in the tool, the overview sheet is also the one, which presents the high level results – the overall Eco Rating, as well as the breakdown of scores across each of the assessment sections.

6.3 LCA basics sheet

6.3.1 General tips and recommendations:

- Many tool questions have scroll down tabs where you can choose from several default options and fill-in fields for more specific data. Where this isn't the case, the tool specifies the measuring unit the data needs to be provided in (i.e. cm²). See below:

Printed Circuit Board (PCB) manufacturing emissions				
	Does the device have this PCB?	Area (cm ²)	Type of PCB	Number of layers
Area of PCB 1 (main board)		67.61	Rigid	18
Area of PCB 2	No			
Area of PCB 3	No			
Area of PCB 4	No			
Total area of other rigid (and flex/rigid combined) PCB	No			
Total area of other flexible PCB	No			

- The tool also provides a comment box for any additional information you want to provide. Based on the answers you fill in, the tool automatically calculates the CO₂ emissions in CO₂e/cm² and in CO₂ impact in grams for each category as below:

kg CO ₂ e :			
	43.52	45%	
Please provide comments or support your answer with evidence	Data check	g CO ₂ e / cm ²	CO ₂ impact (g)
	OK	408.4	22,188.37
	OK	486.9	21,331.09

- Pay attention to the units of assessment:
 - Weight = g
 - Surface area = cm²
 - Energy = mW
 - Time = min or hours
- The value that you fill in for each parameter is limited by a minimum and a maximum boundary. The boundaries provide a measure of control over accidentally entering the wrong data, and have been set based on the realities of the market. However, the market changes, so if your device genuinely falls outside of the parameter scope, please contact us at ecorating@forumforthefuture.org to let us know.

- Where “not known” is selected for an answer, you will be automatically scored using the default maximum value to provide the worst probable case for these criteria.

6.4 LCA basics questions

6.4.1 Screen manufacturing emissions

Screen manufacturing emissions			Type of screen
Area of the main screen (cm ²)	54.33	non-touchscreen	1
Does this device have a secondary screen?	Yes		2
Area of secondary screen (cm ²)	43.81	touchscreen	3

1

Area and type of main screen

a) Enter the type of screen of the mobile phone, selecting either “touchscreen” or “non- touchscreen”.

Note: Display manufacturing contributes a significant proportion of the total handset manufacturing phase impacts. Touchscreens have a higher impact than non-touchscreens do.

b) Fill in the areas of the main screen in cm².

Note: Using the total active area of the screen gives an accurate proxy figure for modelling the total impacts of the screen and is easily-measurable. Only include the active surface of the display panel (i.e. light-emitting or touch-sensitive).

The active area in the figure below is marked in blue. Remember to provide the area in cm² (not diagonal size or number of pixels).



Area used for
the surface of
the display
panel

2

Does this device have a secondary screen?

a) Answer with “Yes” or “No”.

3

Area of secondary screen (cm²)

a) Enter the type of screen of the mobile phone, selecting either “touchscreen” or “non- touchscreen”.

b) Fill in the areas of the main screen in cm².

6.4.2 Printed Circuits Board (PCB) manufacturing emissions

Printed Circuit Board (PCB) manufacturing emissions

	Does the device have this PCB?	Area (cm ²)	Type of PCB	Number of layers
4	Area of PCB 1 (main board)	67.61	Rigid	18
5	Area of PCB 2	Yes	Rigid	
6	Area of PCB 3	Yes	Rigid	13
7	Area of PCB 4	Yes	Rigid	
8	Total area of other rigid (and flex/rigid combined) PCB	No		
9	Total area of other flexible PCB	No		



Area of PCBs (1-4)

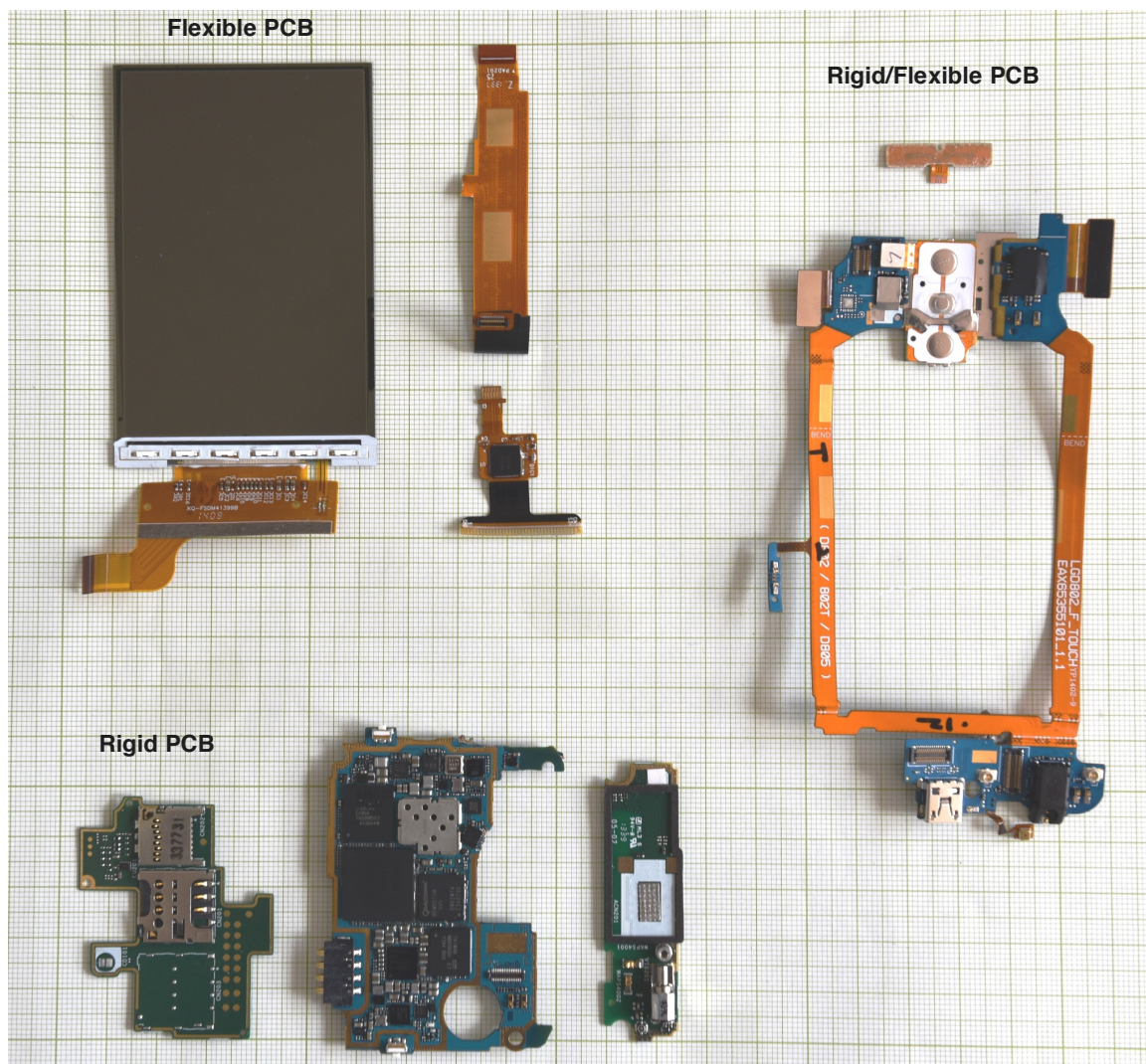
a) Provide the surface area of the main PCB, PCB 2, PCB3, and PCB4 in cm^2 where applicable).

Note: The main PCB, known as the mainboard, holds many of the crucial electronic components of the system, such as processors and memory. The manufacturing of the PCB contributes to the depletion of raw material and, to a lesser extent, global warming. Using the total area of the PCB gives an accurate proxy figure for modelling the total impacts of its manufacture (together with an indication of number of components), and is easily-measurable.

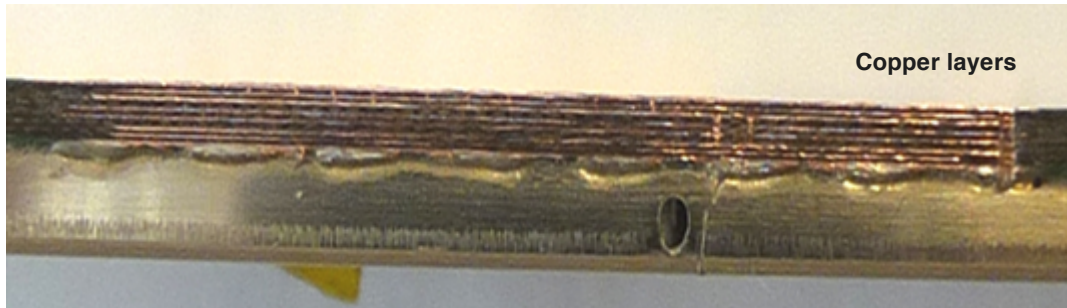
b) Provide the type of PCB, selecting either “Rigid” or “Flexible”.

c) Enter the number of layers the PCB has.

Note: The picture below shows examples for rigid, flexible and rigid/flex PCBs.



The picture below shows a cross-section of a main Printed wiring boards (PWB) or Printed circuit boards (PCB). Simply count the number of layers to get your answer for b). You may need to sand the edge of the PCB/PWB to reveal the copper layers.



8 Total area of other rigid (and flex/rigid combined) PCB

- Give information if the device includes any further rigid PCBs other than already captured in question 4-7. Answer with "Yes" or "No".
- Give specification of size of this additional PCB
- Choose type of PCB: flexible or rigid

9 Total area of other flexible PCB

- Give information if the device includes other rigid PCB other than mentioned in question 4-7. Answer with YES or NO.
- Give specification of size of this additional PCB
- Choose type of PCB: flexible or rigid

6.4.3 Electronic components manufacturing emissions

Electronic components manufacturing emissions

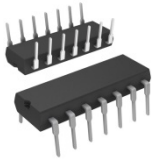
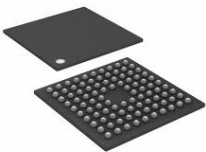
	Do you know the silicon area?	Area (cm2)
10 Area of silicon in integrated circuits with more than 12 pins/balls	Yes	0
	Do you know the NAND flash memory capacity?	Flash memory (GB)
11 NAND flash memory capacity of the device (GB)	Yes	Up to 64 GB

10 Area of silicon in integrated circuits with more than 12 pins/balls

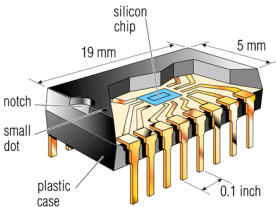
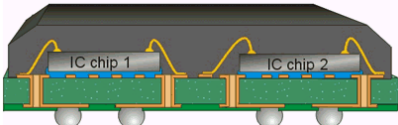
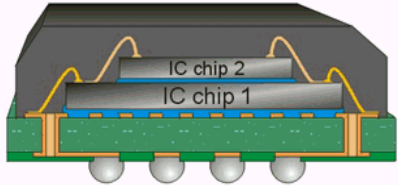
- Find how many integrated circuits with more than 12 connections the mobile phone includes.
- Answer with “Yes”, “No” or “Don’t know”, depending on whether you can specify the size (silicon area) of these integrated circuit boards
- If the answer to b) is “Yes”, enter the total area of silicon in cm^2 .

Note: This part focuses only on the semi-conductor components, which have 12 or more connexions with a PCB. The silicon die area of simple integrated circuits may be calculated by sanding off the packaging and measuring the die area with a Vernier scale.

To help answer question 10a), please refer to the illustrations below, which show the number of pins on a variety of integrated circuits.

Picture	Number of pins
	14
	44
	96

To answer question 10b), find out how many silicon chips/die you have in each integrated circuit and assess the area for all silicon chips/die. The illustrations below should help you identify the number of silicon chips:

Picture	Number of silicon chips	Number of integrated circuits
	1	1
	2	1
	2	1

The silicon chip/die area/surface is a proxy for all the electronic components i.e. integrated circuits and passive components (such as capacitors, resistors and inductors, and electro-mechanical components, such as connectors) soldered on the PCBs. The impact equations we use in the tool are based on a study conducted by Orange³ in 2010, where the company studied 10 different mobile phones' PCB assemblies. This assessment was updated in 2015 with a world mix for GHG emissions of silicon wafer manufacturing and with up-to-date silicon die size for NAND memory (see Appendix 7.3).

11 NAND flash memory capacity of the device (GB)

a) Do you have information about the NAND flash memory capacity? Answer with "Yes" or "No".

b) If known, enter the specific flash memory capacity in gigabytes (GB).

³ Life cycle assessment of mobile phones electronic boards – Orange – 2010 (VAIJA) - contact for further information: samuli.vaija@orange.com

Note: This information helps us to estimate the integrated circuit impacts if the silicon area (question 10) isn't known. Both questions 10 and 11 need to be answered (even if the answer to 10 is "Don't know"), but if an area value is given for question 10 then the proxy in question 11 is not used in the calculations. It will, however, help improve the calculations of the tool.

Silicon chips/dies in NAND integrated circuits are among the largest in mobile phones, especially for high-end models with more than 16GB of memory capacity. That is the reason for why we are using NAND as an alternative way to calculate the environmental impacts in case the silicon area is unknown.

6.4.4 Camera manufacturing emissions

In order to find the best proxy for these manufacturing emissions, Orange carried out teardowns and greenhouse gas emissions assessments for 10 mobile phone cameras⁴, ranging from two megapixels to 16 megapixels with optical zoom and optical image stabilisation (OIS).

Camera manufacturing emissions		
12	Does this phone have a main (rear-facing) camera?	Yes
13a	Does this main camera have an optical zoom?	No
13b	What is the main camera sensor size?	1 / 4"
14	Does this phone have a second (front-facing) camera?	Yes

Camera resolution (in megapixels)
8.0

12 Does this phone have a main (rear-facing) camera?

- a) Answer with "Yes" or "No".
- b) If yes, give information about the megapixels.

Note: If the phone has a main (rear-facing) camera with more than 5.0 megapixel question 13a and 13b open up within the tool in order to specify the impact in more detail.

⁴ Comparative analysis of mobile phone cameras – Orange – 2015 (VAIJA, GARCIA) - contact for further information: samuli.vaija@orange.com

13a **Does this main camera have an optical zoom?**

a) Answer with “Yes” or “No”.

Note: The presence of an optical zoom indicates that the camera is of a higher sophistication and impact, and is scored accordingly

13b **What is the main camera sensor size?**

a) Provide the sensor size of the camera (inch fraction from $\frac{1}{4}$ up to $\frac{2}{3}$).

Note: This question only appears if you answer if question 13a is answered with “No”. If there is no optical zoom, the sensor size is used to calculate the CO₂ impact.

Note: Most mobile phones include an integrated rear-facing camera and associated componentry, the manufacture of which creates additional greenhouse gases and contributes further to raw material depletion. In this case the size of the sensor is the key factor and can be translated into silicon chip/die area to calculate the environmental impacts. A larger sensor equals more environmental impact.

14 **Does this phone have a second (front-facing) camera?**

a) Answer with “Yes” or “No”.

6.4.5 Rest of device manufacturing emissions

Rest of device manufacturing emissions

		Do you know the weight of this component?	weight (g)
15	Weight of plastic in the casing	Yes	2
16	Weight of aluminium in the casing	Yes	70
17	Weight of steel in the casing	Yes	0
18	Battery weight	Yes	34
19	Weight of the rest of the device (excluding casing and battery)	Yes	130
20	Charger weight (enter weight 0 if there is no charger)	Yes	0
21	Weight of documentation (manuals, etc.)		22
22	Weight of packaging		347.5

15 Weight of plastic in the casing

- State whether or not you know the weight of plastic in the casing.
- Provide the total weight of plastic used within the casing in grams.

Note: Casing weights and materials are used to calculate the manufacturing impacts of that component. Plastic has a relatively high CO₂ impact (10.49g CO₂ eq. per gram of material)

It is assumed that plastic casings are composed of ABS (80%) and PC (20%). Appendix 2 provides the secondary data used for the model.

Default value: If you don't know the answer, the tool will assume the worst case scenario of 50g of plastic. The reason why we are so harsh in this case is that we think it is part of the manufacture's responsibility and a hygiene factor to know about this data.

16 Weight of aluminium in the casing

- State whether or not you know the weight of aluminium in the casing.
- Provide the total weight of aluminium used within the casing in grams.

Note: Casing weights and materials are used to calculate the manufacturing impacts of that component. The CO₂ impact of aluminium is 7.91g CO₂ eq. per gram.

It is assumed that the aluminium used in casing is 51% recycled. Table 2 of Appendix 2 presents the secondary data used for the model.

Default value: As for plastic, where the answer is unknown we will assume the worst case scenario of 50g of aluminium.

17

Weight of steel in the casing

a) *State whether or not you know the weight of steel in the casing.*

b) *Provide the total weight of steel used within the casing in grams.*

Casing weights and materials are used to calculate the manufacturing impacts of that component. The CO₂ impact of steel is 4.07g CO₂ eq. per gram.

Table 2 of Appendix 2 presents the secondary data used for the model.

Default value: If you don't know the answer the tool will assume the worst case scenario. The reason why we are so harsh in this case is that we think it's the manufacturer's responsibility and a hygiene factor to know about this data. The default values used are listed in Appendix 1.

18

Battery weight

a) *State whether or not you know the weight of the battery.*

b) *Provide the weight of the battery in grams.*

Note: The total mass of the battery is used as a proxy to calculate the impact of its production. This item has its strongest effect on the global warming indicator.

19

Weight of rest of the device (excluding casing and battery)

a) *State whether or not you know the weight of the rest of the handset.*

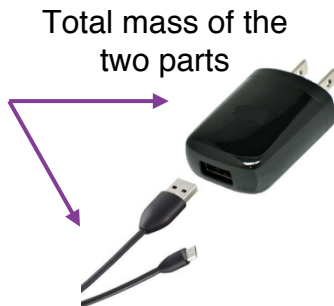
b) *Enter the weight excluding charger and battery in grams.*

Note: The mass of the handset allows evaluating the impacts of the manufacturing of all the handset components. In this section we account for all other components that haven't been captured by the questions above: display, touch-screen, PCB, battery, electronic components (silicon chip/die area conversion), casing. The rest of the device includes components such as, screws gaskets, joints, etc. The manufacturing of those components has a lesser impact on the global warming potential and the depletion of raw materials in comparison with the manufacturing of the screen, PWBs, integrated circuit and silicon chips. Relative to the rest of the handset, the impact of those components is proportional to their total mass.

Table 2 of Appendix 2 presents the secondary data used for the model.

20

Charger weight



- State whether or not you know the weight of the charger.*
- Enter the weight of the charger, including the EPS and the cable.*

Note: The total mass of the charger is used as a proxy to calculate the impact of the production of the charger. This impact has its strongest effect on the raw material indicator

If the phone comes without a charger enter “0” into the weight specification field. In this section you will only be penalised if the device comes with an additional charger. However, in the responsible design section you get extra reward for not providing an additional charger.

Table 2 of Appendix 2 presents the secondary data used for the model.

21

Weight of documentation (manuals, leaflets, flyers)

- State whether or not you know the weight of any additional manuals, leaflets, flyers etc.*
- Enter the weight of the additional documentation in grams.*

Table 2 of Appendix 2 presents the secondary data used for the model.

22

Weight of packaging

- State whether or not you know the total weight of the phone’s packaging.*
- Enter the weight of the total packaging, less the weight of the documentation covered in question 21 in grams.*

Table 2 of Appendix 2 presents the secondary data used for the model.

6.4.6 Transportation emissions

Transportation emissions

23	Location of main manufacturing site	Asia
24	Main mode of transport (by distance) from manufacturing site to final market	Air

23

Location of the main manufacturing site

a) Provide the location of the main production site from the list below. Where production takes place in more than one site, choose the area that manufactures the greatest number of units:

- ☐ Africa
- ☐ Asia
- ☐ North America
- ☐ South America
- ☐ Europe

Note: The location of the main production site is used as a proxy to calculate the impact of the distribution phase, with Asia set as the default manufacturing area. According to China's Ministry of Industry and Information Technology, (MIIT) more than 1.18 billion mobile phones were produced in China in 2012, which is more than half of all the mobile phones sold worldwide this year. Table 2 of Appendix 2 presents the secondary data used for the model.

Continent	Mobile-cellular telephone subscriptions in 2012	
Africa	754 839 895	12.0%
Asia	3 761 993 440	59.6%
Europe	766 520 917	12.1%
Oceania	34 471 307	0.5%
N America	515 360 974	8.2%
S America	482 567 551	7.6%
TOTAL	6 315 754 084	100%

Table 2: Mobile-cellular telephone subscriptions in 2012 used as a proxy to determine the zones of handset distribution

24

Main mode of transport from manufacturing site to final market

a) Provide the main mode of transport from the list below:

- Air
- Rail
- Sea
- Road

Note: The main mode of transport is used as a proxy to calculate the impact of the distribution phase.

Default: As most transport happens by plane currently, air is the default mean of transport. However, you can choose from other transport modes.

Table 2 of Appendix 2 presents the secondary data used for the model.

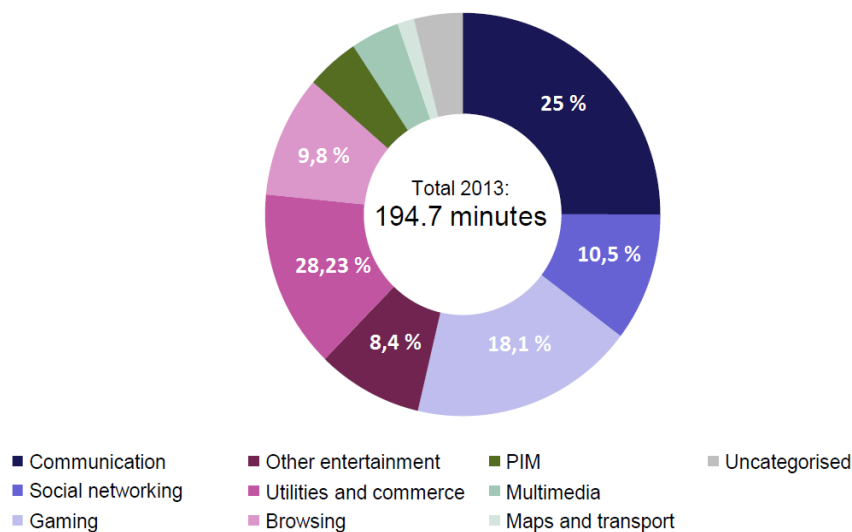
6.4.7 Use phase emissions

Use phase emissions

25	Milliampere-hour (mAh) capacity of the battery	1,500
26	Voltage of the battery	3.7
27	Frequency of charging (touchscreen / non-touchscreen is used as a proxy indicator)	every other day
28	Minimum number of years of use	2

Note: In 2014, Orange carried out a high-end smartphone life cycle assessment⁵. For this study the average time per day spent using various functions and apps on smartphones was established with data provided by Analysys Mason (2014). The figure below displays the distribution:

⁵ High end smartphone life cycle assessment – Orange – 2014 (VAIJA, GARCIA) – contact for further information: samuli.vaija@orange.com



For each function, power consumptions were assessed with teardown data provided by TechInsights; it was found that the batteries had to be recharged on average 60.69% each day (i.e. one charge every 1.65 days).

25

Milliampere-hour capacity of the battery (mAh)

a) Provide the milliampere-hour capacity of the battery in mAh

26

Voltage of the battery

a) Provide the voltage of the battery

27

Frequency of charging is used as proxy indicator

a) If the phone is non-touchscreen we assume that users will charge it phone every other day. Since smartphones use more energy, we assume that users will charge it daily if it includes a touchscreen.

Note: The environmental impact of the use phase emission varies depending on the type of mobile phone.

28

Minimum number of years of use

Note: Based on the average life cycle of mobile phones of 18 months (which is the default contract length for most mobile plans) we used a proxy of two years for the calculation of the user phase emission. This will be reviewed over time and as pricing plans change.

6.4.8 End of life emissions

End of life emissions		
Assumption: French scenario as an average for Europe		
29	Weight of assembled product and the charger (g)	236
30	Weight of battery (g)	34
31	Mobile weight excluding battery (g)	202
32	Area of main printed wiring board (cm2)	67.61

Note: There is no need to provide information in this section as the tool automatically generates the required data that has been provided in previous questions.

Note: Benefits from recycling or energy recovery are not accounted for in this scenario (due to a lack of reliable data), which only takes into account direct impact from transportation and treatment processes.

You can find more detailed information on the end of life scenario in section 3.3.4

6.4.9 Raw material depletion impacts

A study conducted by Orange revealed that gold, silver, tin and tantalum are the raw materials that create the biggest environmental impact during the production of a mobile phone. Based on the weight of these raw materials contained in the mobile phone we can calculate the raw material depletion impact.

A study conducted by Orange revealed that gold, silver, tin, indium and tantalum are the raw materials that create the biggest environmental impact during the production of a mobile phone. Based on the weight of these raw materials contained in the mobile phone we can calculate the raw material depletion impact.

Raw material depletion impacts

	weight (mg)
33 Total weight of gold contained in the device	10.00
34 Total weight of silver contained in the device	20.00
35 Total weight of tin contained in the device	300.00
36 Total weight of tantalum contained in the device	10.00
37 Total weight of indium contained in the device	2.00

33 Total weight of gold contained in the device

a) Enter the total weight of gold that is contained in the device in milligrams.

34 Total weight of silver contained in the device

a) Enter the total weight of silver that is contained in the device in milligrams.

35 Total weight of tin contained in the device

a) Enter the total weight of tin that is contained in the device in milligrams.

36 Total weight of tantalum contained in the device

a) Enter the total weight of tantalum that is contained in the device in milligrams.

37 Total weight of indium contained in the device

a) Enter the total weight of indium that is contained in the device in milligrams.

6.5 Responsible design sheet

6.5.1 Product durability, repairability and serviceability

A) Product durability, repairability and serviceability

How many years' service/warranty support are made available by the manufacturer (where a sale presence is maintained) after purchase?

3

38

Is this mobile phone ITU-T L.1000 compliant? This is a standard covering the universal power adapter and charger solution for mobile phones

Yes

39

Can the mobile phone be disassembled - using standard tools - to allow access to key components for repair or for reuse at end of life?

Battery	With specialist tools (not readily available to the general public)
Front and back casing	By hand without tools
Display - e.g. (LCD, OLED, touchscreen, etc.)	By hand without tools
Main PCB/s	By hand without tools
Keyboard	With specialist tools (not readily available to the general public)

40

Does this mobile phone contain modular componentry for all of its components that allows the user to reconfigure the device as they choose?

No

41

Do you provide instructions to the user on the mobile phone on how contacts and other personal information can be transferred to a different phone?

Yes

42

Do you provide instructions to the user on the mobile phone on how all personal data on the device can be wiped (e.g. at end of use)?

Yes

43

Product durability and life extension

Gate	0
Data missing	0
Maximum points available	32
Points attained	16
Score	0.50

44

38

How many years' service/warranty support are made available by the manufacturer (where a sale presence is maintained) after purchase?

a) Enter the number of years of service support available for the device.

Note: Prolonging product life is one of the most effective ways of reducing overall product environmental impact as it delays the need for a replacement and hence use of additional natural resources and carbon emissions.

39

Is this mobile phone ITU-T L.1000 compliant?

a) Answer with "Yes" or "No".

Note: This is a standard covering the universal power adapter and charger solution for mobile phones.

Incompatibility of chargers for mobile phones is a major environmental problem creating significant quantities of electronic waste. Harmonising mobile phone chargers will bring significant economic and environmental benefits, as consumers will not need to buy a new charger with every mobile phone.

40 Can the mobile phone be disassembled - using standard tools - to allow access to key components for repair or for reuse at end of life?

a) Answer with “Yes” or “No” to each of the eight components listed.

Note: This question is trying to establish how easily key components can be accessed through disassembly to allow repair or reuse. Allowing access by standard tools facilitates repair by non-specialist repairers and can therefore help to reduce the price of repair, making it more economical. Prolonging product life through repair is one of the most effective ways of reducing overall product environmental impact.

41 Does this mobile phone contain modular componentry for all of its components that allows the user to reconfigure the device as they choose?

a) Answer with “Yes” or “No”.

Note: Modular devices, in which every major component (such as battery, screen, camera, keypad, processor, motherboard, memory, chassis, etc.) can be simply removed and switched by the user, are being developed by a variety of organisations. Modularity has the potential to reduce waste and manufacturing impacts of new devices by allowing only those parts of a device that are broken or obsolete to be replaced, rather than disposing of the whole device.

42 Do you provide instructions to the user on the mobile phone on how contacts and other personal information can be transferred to a different phone?

a) Answer with “Yes” or “No”.

Note: Being able to easily transfer personal data from an old phone to a new one gives the user confidence that none of their important personal history will be lost if they no longer own the old phone. This should allow the old phone to be more readily reused or recycled (rather than kept for information insurance purposes), hence reducing overall resource demands. Having this information on the device itself makes this process easier and gives additional confidence that it has been done correctly.

43 Do you provide instructions to the user on the mobile phone on how all personal data on the device can be wiped (e.g. at end of life)?

a) Answer with “Yes” or “No”.

Note: Being able to easily remove all personal data from an old phone to a new one gives the user confidence that none of their important personal history will remain on the device. This should allow the old phone to be more readily reused

or recycled (rather than kept for information insurance purposes), hence reducing overall resource demands. Having this information on the device itself makes this process easier and gives additional confidence that it has been done correctly.

44 Summary boxes

Throughout the spread sheet are orange summary boxes that show the number of answers in the section that are missing, the maximum points that were available and gained for the section, and the overall score for the section. If any answers are missing, no score will be given for that section and there will be no final Eco Rating score given either.

The summary boxes also show the number of 'gate' questions that have been failed. These are critical questions where failure to meet the criterion (e.g. being compliant with the European Union (EU) REACH Directive) means the device automatically fails the minimum acceptability test and will not get an Eco Rating score. Gate questions are rare in the assessment and are usually included to encourage an improvement of standards in global markets; for instance, by including the EU REACH Directive requirement encourages a basic minimum standard globally even in areas where REACH is not mandatory.

6.5.2 Power conservation

B) Power conservation

Does the phone pro-actively advise (in the manual, or on the phone display) on sustainable phone usage to reduce energy use?	Yes
Does the mobile phone include a feature that lowers it's power consumption by switching off all background running applications and non-used network connections, and reduces the screen's brightness and standby time, with one single action?	Yes
Is the mobile phone able to use H.265 / HEVC codec in order to encode and decode video?	Yes
Does the mobile phone include a low-power-consumption co-Processor, can the main CPU's clock frequency be throttled down (dynamic frequency scaling) or can the main CPU's unused cores be switched to their lowest power mode/ be switched off when they're not used (for mobile phones with multi-core CPU)?	Yes
Does the CPU's architecture include L3 cache memory?	Yes
Is the mobile phone Bluetooth 4.2 compatible?	Yes
Does the manufacturer-specified external power supply meet the ITU-T L.1000 requirements for energy efficiency (a no-load power consumption below 0.15 W)?	No

45

46

47

48

49

50

51

- 45 Does the phone proactively advise (in the manual or on the phone display) on sustainable phone usage to reduce energy use?
-

a) Answer with “Yes” or “No”.

Note: Phone energy use is closely related to transfer of large amounts of data, such as constantly updating email accounts or operating certain web-based apps (e.g. for maps and navigation). Bluetooth and Wi-Fi also use a lot of energy. This means that the battery has to be recharged more frequently, which in turn means it has a shorter life. Providing guidance helps users to manage energy use better.

- 46 Does the mobile phone include a feature, which lowers the mobile phone’s power consumption by switching off all background running applications and non-used network connections, and reduces the screen’s brightness and standby time, with one single action?
-

a) Answer with “Yes” or “No”.

Note: These are features that lower the mobile phone’s power consumption and improve energy efficiency during the usage phase.

- 47 Is the mobile phone able to use H.265/HEVC codec in order to encode and decode video?
-

a) Answer with “Yes” or “No”.

Note: H.265/HEVC is a video compression standard that provides substantially improved video quality at the same bit rate as its predecessor, H.264/MPEG-4 AVC, and therefore reduces the overall energy usage of the phone.

- 48 Does the mobile phone include a low power consumption co-processor or can the main CPU’s clock frequency be throttled down (dynamic frequency scaling) or can the main CPU’s unused cores be switched to their lowest power mode/be switched off when they’re not used (for mobile phones with multi-core CPU)?
-

a) Answer with “Yes” or “No”.

Note: The ability to use only as much of the central processing unit (CPU) as is needed for a task at any one time reduces the overall power consumption of the device.

49 Does the CPU's architecture include L3 cache memory?

a) Answer with "Yes" or "No".

Note: The L3 cache is usually built onto the motherboard between the main memory (RAM) and the L1 and L2 caches of the processor module. This serves as internal data storage for processor commands and frequently used data. It helps to prevent bottlenecks resulting from the fetching of these data from the main memory.

L3 cache memory adds extra memory capacity with better specifications (e.g. access time/latency, transfer rate) than SDRAM. Therefore, with similar processing performance a CPU with L3 cache memory can have a lower frequency, thus a lower power consumption.

50 Is the mobile phone Bluetooth 4.2 compatible?

a) Answer with "Yes" or "No".

Note: Bluetooth 4.2 is more power efficient than their successor and can reduce the overall power usage of the mobile phone during its usage.

51 Does the manufacturer-specified external power supply meet the ITU-T L.1000 requirements for energy efficiency (a no-load power consumption below 0.15 W)?

a) Answer with "Yes" or "No".

Note: ITU-T L.1000 requires a universal power adapter and charger solution that will reduce the number of adapters and chargers produced and recycled by widening their application to more devices and increasing their lifetime. The solution also aims to reduce energy consumption. The longer life cycle and possibility of avoiding device duplication reduces the demand on raw materials and waste. The universal power adapter and charger solution is designed to serve the vast majority of mobile terminals and other ICT devices.

6.5.3 Sustainable materials

C) Sustainable materials

What percentage of aluminium used (e.g. in the case) is part consumer recycled (i.e. scrap) content?		52
What percentage of the internal tool (e.g. the chassis) and an external tool (e.g. case) components is part consumer recycled (i.e. scrap) content?		53
What percentage of the plastic used in the mobile phone (e.g. the case and elsewhere), is part consumer recycled (i.e. scrap) content?		54
Does the mobile phone (including packaged accessories) meet the requirements of the current EU RoHS Directive provisions (including applicable exclusions and exemptions)?	Charge	55
Does the mobile phone (including packaged accessories) meet all applicable requirements of the current EU REACH Directive (current restrictions are) provisions for all markets where the product is sold?	Charge	56
Do printed circuit board laminates in the mobile phone (including packaged accessories) meet the Br and Cl restrictions (900 ppm maximum chlorine; 900 ppm maximum bromine; 1500 ppm maximum total halogens) as per the requirements of IEC 61249-2?	Charge	57
Does the mobile phone battery meet the requirements of the current EU Battery Directive (including applicable exclusions and exemptions) for all markets where manufacturers sell their products?	Charge	58
Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with? NOTE that 'absent' refers to a Maximum Concentration Value (MCV) for each substance of 1000ppm (0.1% by weight) by homogeneous material <u>unless otherwise specified</u> .	All chlorinated polymers including polyvinylchloride (PVC), PVC blends and chloroprene rubbers e.g. [CAS 9002-86-2 +]	Charge 59
	Short chain (SCCPs) and medium chain (MCCPs) chlorinated paraffins e.g. [CAS 85535-84-8] & [CAS 85535-85-9]	Charge 60
	Antimony trioxide where used in conjunction with flame retardants [CAS 1309-64-4]	Charge 61
	Beryllium & compounds (e.g. beryllium oxide) e.g. [CAS 7440-41-7], [CAS 1304-56-9], [CAS 12228-40-9], [CAS 7787-46-4], [CAS 543-81-7]	Charge 62
	Benzene & compounds (e.g. Hexachlorobenzene) e.g. [CAS 71-43-2] [CAS 118-74-1]	Charge 63
	Perchlorate (e.g. as used in batteries) e.g. [CAS 14797-73-0]	Charge 64
	Perfluorooctanesulfonate (PFOS) and Perfluorooctanoic acid (PFOA) (maximum combined concentration value 10ppm) e.g. [CAS 335-67-1]	Charge 65
	Phthalate e.g. [CAS 85-68-7], [CAS 117-81-7], [CAS 84-74-2], [CAS 84-69-5], [CAS 84-66-2]	Charge 66
	Brominated & Halogenated flame retardants e.g. [CAS 3296-90-0], [CAS 96-13-9], [CAS 3194-55-6], [CAS 201-236-9]	Charge 67
	Other chlorinated & halogenated hydrocarbons e.g. [CAS 115-96-8]	Charge 68
	Nickel (where used in surface parts in contact with the skin) [CAS 7440-02-0]	Charge 69
	Other Antimony compounds e.g. [CAS 54538-98-9], [CAS 13958-41-7], [CAS 127153-81-5], [CAS 126426-74-2], [CAS 89899-81-0], [CAS 77824-44-3]	Charge 70

- 52 What percentage of aluminium used (e.g. in the case) is post-consumer recycled (i.e. scrap) content?
-

a) Enter a value from 0% - 100%.

Note: The manufacture of aluminium is very energy intensive. Producing it from recycled materials reduces the energy required by ~95% compared with producing it from the mineral bauxite, which helps to reduce global warming and create greater demand for aluminium waste.

- 53 What percentage of the internal steel (e.g. the chassis) and or external steel (e.g. case) components is post-consumer recycled (i.e. scrap) content?
-

a) Enter a value from 0% - 100%.

Note: Manufacturing steel is an energy intensive process, but making it from recycled materials requires less energy compared with making it from iron ore. This helps to reduce global warming and create greater demand for steel scrap.

- 54 What percentage of the plastic used in the mobile phone (e.g. the case and elsewhere), is post-consumer recycled (i.e. scrap) content?
-

a) Enter a value from 0% - 100%.

Note: Substituting post-consumer recycled plastic for virgin plastic saves energy and reduces emissions of global warming gases.

- 55 Does the mobile phone (including packaged accessories) meet the requirements of the current EU RoHS Directive provisions (including applicable exclusions and exemptions)?
-

a) Answer with "Yes" or "No".

Note: The Restriction of Hazardous Substances Directive 2002/95/EC (RoHS) was adopted in February 2003 by the EU, and restricts the use of lead (Pb), mercury (Hg), cadmium (Cd), hexavalent chromium (Cr6+), polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PBDE). It is not mandatory in all parts of the world, so its inclusion here helps the Eco Rating drive higher standards globally.

- 56 Does the mobile phone (including packaged accessories) meet all applicable requirements of the current EU REACH Directive (current restrictions on use) provisions for all markets where the product is sold?
-

a) Answer with "Yes" or "No".

Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) is an EU directive that addresses the production and use of chemical substances and their potential impacts on both human health and the environment. It is the strictest law to date regulating chemical substances and will affect industries throughout the world. However, it is not mandatory in all parts of the world, so its inclusion here helps the Eco Rating drive higher standards globally.

57 Do printed circuit board laminates in the mobile phone (including packaged accessories) meet the Br and Cl restrictions (900 ppm maximum chlorine; 900 ppm maximum bromine; 1500 ppm maximum total halogens) as per the requirements of IEC 61249-2?

a) Answer with “Yes” or “No”.

Note: This standard covers materials for printed boards and other interconnecting structures, and is designed to limit the total concentrations of halogens. The disposal (usually by incineration) of halogenated materials releases dioxins and furans – which are highly toxic have been shown to accumulate in soil, water and humans - into the atmosphere.

58 Does the mobile phone battery meet the requirements of the current EU Batteries Directive (including applicable exclusions and exemptions) for all markets where manufacturers sell their products?

a) Answer with “Yes” or “No”.

Note: The directive aims at minimising the negative impacts of batteries and accumulators on the environment, as well as harmonising requirements for the smooth functioning of the internal market. To achieve these objectives, the directive includes measures to prohibit the marketing of certain batteries containing hazardous substances, as well as guidance on how to establish ambitious battery collection and recycling schemes with quantified targets. The directive sets out minimum rules for producer responsibility and provisions with regard to labelling of batteries and their removability from equipment.

59 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: all chlorinated polymers, including polyvinylchloride (PVC); PVC blends; and chloroprene rubbers?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

PVC and chloroprene rubbers are made from hazardous monomers that can contain toxic plasticisers and heavy metal stabilisers, and can create dioxins if burnt at relatively low temperatures (i.e. rather than high temperature incineration). PVC is being considered for inclusion in a forthcoming revision of RoHS.

60 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: short chain (SCCPs) and medium chain (MCCPs) chlorinated paraffins?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

SCCPs are persistent, bioaccumulative, toxic to aquatic organisms and possibly carcinogenic to humans (category 2B).

61 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: antimony trioxide where used in conjunction with flame retardants?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

Antimony and many of its compounds are toxic and the effects are similar to arsenic, causing headaches, dizziness, depression, dermatitis, damage to the kidneys and the liver, and potentially death. It is also a suspected carcinogen.

62 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: beryllium and compounds (e.g. beryllium oxide)?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

BeO is carcinogenic and may cause chronic beryllium disease, a chronic allergic-type lung response and chronic lung disease. Inhalation of dust or fumes from copper-beryllium can cause serious pulmonary illness (lung disease) and BeO can be formed from alloys during processing.

- 63 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: benzene and compounds (e.g. hexachlorobenzene)?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

Benzene increases the risk of cancer and bone marrow failure.

- 64 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: perchlorates (e.g. as used in batteries)?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

Perchlorate, in large amounts, interferes with iodine uptake into the thyroid gland. In adults, the thyroid gland helps regulate the metabolism by releasing hormones, while in children, the thyroid assists in proper development.

- 65 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: perfluoro octane sulfonates (PFOS) and Perfluoro octanic acids (PFOA)?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum combined concentration value of 10ppm in all cases by homogenous material.

PFOS has been restricted (less than 0.001% by weight) for some time in the EU market. PFOA is on the REACH candidate list. PFOS and PFOA are persistent organic pollutants and are associated with increased risk of chronic kidney disease.

- 66 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: phthalates?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

Phthalates are mainly used as plasticisers to increase the flexibility, transparency, durability and longevity of plastics. They can, however, leach out

of plastics and act as endocrine disruptors for those that absorb them. They also potentially have other serious health effects. Phthalates are being considered for inclusion in a forthcoming revision of RoHS.

67 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: brominated/halogenated flame retardants?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

Brominated flame retardants (BFRs) are persistent, bioaccumulative and toxic to both humans and the environment, and are suspected of causing neurobehavioral effects and endocrine disruption. BFRs are being considered for inclusion in a forthcoming revision of RoHS.

68 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: other chlorinated and halogenated hydrocarbons?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

This restriction refers to substances such as toluene, xylenes and trichloroethylene, which have serious health and/or eco-toxic effects.

69 Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: nickel (where used in surface parts in contact with the skin)?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

Sensitised individuals may show an allergy to nickel, affecting their skin (also known as dermatitis). The amount of nickel allowed in products that come into contact with human skin is regulated by the EU.

70

Are the following substances absent from this mobile phone and all of the materials (including packaged accessories) it is supplied with: other antimony compounds?

a) Answer with “Yes” or “No”.

Note: 'Absent' refers to a maximum concentration value (MCV) for each substance of 1000ppm (0.1% by weight) by homogenous material.

Antimony and many of its compounds are toxic. Rather than trying to specify every known compound for which this is the case, this question adopts the precautionary principle.

6.5.4 Packaging and logistics efficiency

D) Packaging and logistics efficiency

Weight of mobile phone including battery in grams	236.00	
Weight of packaged accessories (e.g. headsets, chargers, cables) in grams	0.00	
Weight of accompanying materials (manuals, etc.) in grams	22	Total product weight
Weight of packaging materials in grams	347.50	Product: Packaging ratio
Volume of packaging (cm ³)	23	71
Volume of mobile phone (cm ³)	22	
Percentage of void space (%)	4.3%	

The impact calculation for the volume of packaging is made as follows:

$$CO_{2\text{pack.}}(m_{\text{pack.}}) = 49.80gCO_{2\text{eq.}} + 0.737 \times m_{\text{pack.}}$$

71

Volume of packaging and volume of mobile phone

a) Enter the total volume of packaging and the total volume of the mobile phone in cm³. The tool will automatically calculate the total product weight and packaging ratio based on this data.

Note: Together, these questions provide a measure of the weight of the packaging relative to the weight of the device. Packaging should be optimised so that only enough is used to provide the necessary level of protection of the

product. This is more efficient for the manufacturer and causes a lower environmental impact.

By giving the information on volumes, the tool calculates the “void space”, which is a measure of the emptiness of the packaging. Minimising the void space wherever possible will increase the amount of product that can be fitted into a load during the transport phase, and therefore reduce associated emissions.

Where more than one material type is used (including different plastic polymers), are these material types fully separable into recyclable material streams at end of life, i.e. they are not bonded or laminated?		72	Yes
1) Paper and card content	Weight in grams - Enter "0" if not applicable	73	247.5
	Is this material from a Forest Stewardship Council, Sustainable Forestry Initiative, or equivalent certified sustainable source?	74	Yes
	Recycled content (%)	75	
	Is this material marked with the internationally recognised paper recycling symbol?	76	No
2) Plastic content	Weight in grams - Enter "0" if not applicable	77	100.0
	Recycled content (%)	78	45%
	Is this material marked with the internationally recognised recycling symbol for the polymer type according to ISO 11469-2000?	79	Yes
3) Other materials	Weight in grams - Enter "0" if not applicable	80	0.0
	Recycled content (%)	81	
	Is this material marked with the relevant international recycling symbol for the material type?	82	

72 Where more than one material type is used (including different plastic polymers), are these material types fully separable into recyclable material streams at end of life, i.e. they are not bonded or laminated?

a) Answer with “Yes” or “No”. Choose “1 material type only” if only one material type is used.

Note: Recyclability of packaging materials can only be achieved domestically (the route that most of the device packaging will go down) if it can be easily separated into its constituent materials; bonded or laminated materials currently make it less likely that packaging will be recycled.

73 77 80 Weight of materials

a) Enter the weight of stated materials in grams.

Note: These questions are used to check that the total packaging weight is the same as the individual material weights. It is also used to assign a “sustainable materials packaging score”, which is related to the total weight of all packaging materials that is made from sustainable sources.

This avoids packaging being scored too highly. For example, consider 100g of a material that is made up of 98g of virgin paper and 2g of recycled plastic. In this case, 100% of the plastic would be marked as being made of recycled content, but the total proportion of the material is still very low. Similarly, it also stops packaging being scored too low if not all materials are from sustainable sources, but the majority of the total weight is.

74 Is this material from Forest Stewardship Council, Sustainable Forestry Initiative or equivalent certified sustainable source?

a) Answer with “Yes” or “No”.

Note: We know that paper can come from a variety of sustainable sources, and this question asks whether it has come from a source that certifies the sustainable production of timber. In some cases, this is a more attractive option for manufacturers than using recycled content because of differences in availability of high quality product.

75 78 81 Recycled content of materials (%)

a) Enter the percentage of recycled content in the material.

Note: Reusing materials helps close the loop on resource use. Rather than being a linear flow – extract materials, manufacture, use, dispose of, extract more materials, etc. – it instead encourages a circular flow – extract materials, manufacture, use, recycle, re-manufacture, re-use, etc. Closing the loop helps meet with world’s increasing demand for finite resources.

76 79 82 Is this material marked with the relevant international recycling symbol for the material type (paper / polymer / other)?

a) Answer with “Yes” or “No”.

Note: Making a material from a recyclable material doesn’t guarantee that it will be recycled. Marking it with recycling symbols increases the likelihood of it being recycled by giving consumers the information they need to recycle it responsibly if the facilities exist.

The standard international recycling symbols for plastics are:



Packaging weight error indicator		83
Are the printing inks used on all printed materials from non petroleum based sources?	Choose	84
When not enforced by applicable regulation (e.g. Safety legal regulation), does this device come without: a physical manual (either paper or on a CD)?	Choose	85

83 Packaging weight error indicator

a) No answer required.

Note: This checks that the quantities of each packaging material (by weight in grams) add up to the same total as the weight given in Question 71.

84 Are the printing inks used on all printed materials from non-petroleum based sources?

a) Answer with “Yes” or “No”.

Note: Petroleum-based printing inks not only come from non-renewable sources (fossil fuels), but also release volatile organic compounds (VOCs) which reduce indoor air quality and can pose negative health risks. The emissions per unit of packaging may be small, but the use of petroleum-based inks in the packaging manufacture may have much more serious impacts. High quality non-petroleum based inks are available that use natural organic materials.

85 When not enforced by applicable regulation (e.g. safety legal regulation), does this device come without a physical manual (either paper or on a CD)?

a) Answer with “Yes” or “No”.

Note: Manuals are often redundant nowadays, since the set-up instructions are usually provided on the phones themselves during start up, with electronic manuals available on the device itself or through links to online resources.

Removing manuals therefore saves resources and weight for manufacturers, and reduces waste for consumers. We recognise, however, that regulations in parts

of the world may make it impossible to remove manuals from the box, even if manufacturers would like to.

6.5.5 Disposable impacts

E) Disposal impacts	
What proportion of the mobile phone can be separated out into pure (99.9%) material streams after shredding	86

86 What proportion of the mobile phone can be separated out into pure (99.9%) material streams after shredding?

a) Enter a percentage.

Note: The hi-tech recycling solution for electronic devices is currently to shred them into small fragments and use sophisticated sorting technology to separate those fragments out into different material types. High recovery rates are possible so long as the fragments are of one material type, but if a device contains parts that tightly-bonded composites of different materials then those parts will not be able to be separated into pure (deemed 99.9% or higher) material streams.

This question asks for the proportion of the total device that is comprised of materials and components that can be separated after mechanical shredding into pure material streams.

6.5.6 Functionality

F) Functionality	
Hardware	
Does this mobile phone replace the need for a digital compact camera by including a camera with a sensor with a diagonal larger than 1/2.33 inch ?	Yes 8
Does this mobile phone include a real-time navigational device (e.g. satellite navigation)?	Yes 8
Does this mobile phone have a front-facing camera for video-conferencing capabilities (between two or more people)?	Yes 8

- 87 Does this mobile phone replace the need for a digital compact camera by including a camera with a sensor with a diagonal larger than 1/2.22 inch?
-

a) Answer with “Yes” or “No”.

Note: This question assumes that if the mobile phone replaces the need for a digital compact camera it could reduce consumption by potentially replacing the purchase of a new compact camera.

- 88 Does this mobile phone include a real-time navigational device (e.g. satellite navigator)?
-

a) Answer with “Yes” or “No”.

Note: This question assumes that if the mobile phone includes a real-time navigational device it could reduce consumption by replacing the purchase of a new navigation device.

- 89 Does this mobile phone have a front-facing camera for videoconferencing capabilities (between two or more people)?
-

a) Answer with “Yes” or “No”.

Note: This question assumes that if the mobile phone includes a front-facing camera it potentially could reduce the need to travel to (e.g. for business meetings).

7 Appendices

7.1 Appendix 1: Default values

7.1.1 Table 1: Default values

Question	Default value
How many screens are included in the product?	1
What is the active area of screen one (i.e. main screen), in cm ² ?	88
Is screen one (i.e. main screen) a touchscreen?	Yes
What is the active area of screen two0, in cm ² ?	13.5
Is screen two a touchscreen?	No
What is the area of silicon in the integrated circuits with more than 12 pins/balls, in cm ² ? Silicon area in stacked, flip-chip/wafer-level CSP, system-in-package, package-on-package and multi-chip integrated circuits should be included.	20.0001
What is the NAND flash memory capacity of the device? (in Gb)	64
Is there a main Printed Wiring Board (PWB) or Printed Circuit Board (PCB) in the device?	Yes
What is the external area of the main PWB or PCB, in cm ² ?	66.5
Is the main PWB or PCB a flexible circuit board?	No
Number of layers in the main PWB or PCB?	14
Is there a second PWB or PCB in the device?	Yes
What is the external area of the second PWB or PCB, in cm ² ?	27.4
Is the second PWB or PCB a flexible circuit board?	No
Number of layers in the second PWB or PCB?	14
Is there a third PWB or PCB in the device?	Yes
What is the external area of the third PWB or PCB, in cm ² ?	27.3972
Is the third PWB or PCB a flexible circuit board?	No
Number of layers in the third PWB or PCB ?	14
Is there a fourth PWB or PCB in the device?	Yes
What is the external area of the fourth PWB or PCB, in cm ² ?	20
Is the fourth Printed Wiring Board (PWB) or Printed Circuit Board (PCB) a flexible circuit board?	No
Number of layers in the fourth PWB or PCB?	14
What is the total external area of all others rigid PWB or PCB or flex/rigid combined PWB or PCB, in cm ² ?	89.35
What is the total external area of all others flexible PWB or PCB, in cm ² ?	83.9
Does this main camera have an optical zoom?	No
What is the resolution of the main camera (in megapixels)?	15
What is the main camera sensor size in inch fraction?	2/3
Does this phone have a second (front-facing) camera?	No
What is the weight of the receiver with its battery, in g?	178.5

What is the weight of the charger (or adaptor) with the cable, in g?	75.8
What is the weight of the battery, in g?	54
What is the weight of plastic composing the handset case, in g?	50
What is the weight of aluminium composing the handset case, in g?	50
What is the weight of steel composing the handset case, in g?	0
What is the weight of the packaged finished product, in g?	870
Where is the location of the main manufacturing site (Asia, North America, South America, Africa or Europe)?	Asia
What is the absorbed energy to charge the battery from 0 to 100% (on the side of mains), in mWh?	15317.3
What is the quantity of indium contained in the device (including solders, electronic components), in mg?	15
What is the quantity of gold contained in the device (including all gold coating, gold wire, gold flash), in mg?	84.51
What is the quantity of silver contained in the device (including solders, electronic components), in mg?	500.01
What is the quantity of tantalum contained in the device (including solders, electronic components), in mg?	15
What is the quantity of tin contained in the device (including solders, electronic components), in mg?	1806.01
How many years' service/warranty support are made available by the manufacturer (where a sale presence is maintained) after purchase?	0
Is this mobile phone ITU-T L.1000 compliant? This is a standard covering the universal power adapter and charger solution for mobile phones.	No
Does this mobile phone contain modular componentry for all of its components that allows the user to reconfigure the device as they choose?	No
Do you provide instructions to the user on the mobile phone on how contacts and other personal information can be transferred to a different phone or wiped (e.g. at end of use)?	No
Can the mobile phone be disassembled - by hand, or using standard tools - to allow access to key components for repair or for reuse at end of life?	No
Can the mobile phone be disassembled - by hand, or using standard tools - to allow access to battery for repair or for reuse at end of life?	No
Can the mobile phone be disassembled - by hand, or using standard tools - to allow access to the display (LCD, OLED...) or the touch screen (capacitive, resistive...) for repair or for reuse at end of life?	No
Can the mobile phone be disassembled - by hand, or using standard tools - to allow access to casing for repair or for reuse at end of life?	No
Are the main electronic cards (PWB or PCB) repairable?	No
Does the phone pro-actively advise (in the manual or on the phone display) on sustainable phone usage to reduce energy use?	No
Does the manufacturer-specified external power supply meet the ITU-T L.1000 requirements for energy efficiency no-load power consumption below 0.15 W?	No

Does the mobile phone include a feature that lowers its power consumption by switching off all background running applications and non-used network connections, and reduces the screen's brightness and standby time, with one single action?	No
Is the mobile phone able to use H.265 / HEVC codec in order to encode and decode video?	No
Does the mobile phone include a low power consumption co-processor, can the main CPU's clock frequency be throttled down (dynamic frequency scaling) or can the main CPU's unused cores be switched to their lowest power mode/ be switched off when they're not used (for mobile phones with multi-core CPU)?	No
Does the CPU's architecture include L3 cache memory?	No
Is the mobile phone Bluetooth 4.2 compatible?	No
Is this mobile phone designed to enable reuse of components?	No
What percentage of aluminium used (e.g. in the case) is post-consumer recycled (i.e. scrap) content, in %?	0
What percentage of the internal steel (e.g. the chassis) and or external steel (e.g. case) components is post-consumer recycled (i.e. scrap) content, in %?	0
What percentage of the plastic used in the mobile phone (e.g. the case and elsewhere), is post-consumer recycled (i.e. scrap) content, in %?	0
Do PCB laminates in the mobile phone (including packaged accessories) meet the Br and Cl restrictions (900 ppm maximum chlorine; 900 ppm maximum bromine; 1500 ppm maximum total halogens) as per the requirements of IEC 61249-2?	No
Is polyvinyl chloride (PVC) and its compounds (PVC blends and chloroprene rubbers) contained in the device? [CAS 9002-86-2]	Yes
Is polyvinyl chloride (PVC) and its compounds (PVC blends and chloroprene rubbers) contained in the charger (including cords), USB cable or any other accessories? [CAS 9002-86-2]	Yes
Are short chain (SCCPs) and medium chain (MCCPs) chlorinated paraffins and their compounds contained in the device or all of the materials (including packaged accessories)? (e.g. [CAS 85535-84-8] and [CAS 85535-85-9])	Yes
Is antimony (Sb) and its compounds contained in the device or all of the materials (including packaged accessories)? (antimony trioxide (Sb ₂ O ₃) [CAS 1309-64-4]; antimony (Sb) [CAS 7440-36-0]; antimony trioxide (Sb ₂ O ₃) [CAS 1309-64-4])	Yes
Are other antimony compounds contained in the device or all of the materials (including packaged accessories) e.g. [CAS 545386-98-9], [CAS 139598-41-7], [CAS 127153-81-5], [CAS 126426-74-2], [CAS 89899-81-0], [CAS 77824-44-3]?	Yes
Is beryllium (Be) and its compounds contained in the device or all of the materials (including packaged accessories)? (beryllium (Be) [CAS 7440-41-7]; beryllium oxide (BeO) [CAS 1304-56-9], [CAS 12228-40-9], [CAS 7787-46-4], [CAS 543-81-7])	Yes
Is benzene and its compounds (e.g. hexachlorobenzene) contained in the device or all of the materials (including packaged accessories)? [CAS 71-43-2] or [CAS 118-74-1]	Yes
Are lithium perchlorates (LiClO ₄) and their compounds contained in the device or all of the materials (including packaged accessories)? [CAS 14797-73-0] (e.g. as used in batteries)	Yes

Are perfluoro octane sulfonates (PFOS) and perfluoro octanic acids (PFOA) and their compounds contained in the device or all of the materials (including packaged accessories)? [CAS 335-67-1]	Yes
Are phthalates (DBP and DEHP) and their compounds contained in the device? (e.g. benzyl butyl phthalate (BBP) [CAS 85-68-7]; Di-(2-ethylhexyl)phthalate (DEHP) [CAS 117-81-7]; di-n-butylphthalate (DBP) [CAS 84-74-2]; diisobutylphthalate (DiBP) [CAS 84-69-5]; Diethyl phthalate (DEP) [CAS 84-66-2])	Yes
Are phthalates (DBP et DEHP) and their compounds contained in the charger (including cords), USB cable or any other accessories? (e.g. benzyl butyl phthalate (BBP) [CAS 85-68-7]; Di-(2-ethylhexyl)phthalate (DEHP) [CAS 117-81-7]; di-n-butylphthalate (DBP) [CAS 84-74-2]; diisobutylphthalate (DiBP) [CAS 84-69-5]; Diethyl phthalate (DEP) [CAS 84-66-2])	Yes
Are brominated and halogenated flame retardants and others compounds contained in the device or all of the materials (including packaged accessories)? (brominated flame retardants: dibromo-neopentyl-glycol [CAS 3296-90-0]; 2,3-dibromopropan-1-ol; 2,3-dibromo-1-propanol [CAS 96-13-9]; hexabromocyclododecane [CAS 3194-55-6] ; tetrabromobisphenol A [CAS 201-236-9]; Brominated flame retardants: dibromo-neopentyl-glycol [CAS 3296-90-0] 2,3-dibromopropan-1-ol; 2,3-dibromo-1-propanol [CAS 96-13-9] hexabromocyclododecane [CAS 3194-55-6] tetrabromobisphenol A [CAS 201-236-9] Other brominated flame retardants)	Yes
Are chlorinated and halogenate hydrocarbons and other compounds contained in the device or all of the materials (including packaged accessories)? (e.g. tris(2-chloroethyl)phosphate [CAS 115-96-8])	Yes
Is nickel (Ni) and its compounds used in surface parts likely to be in contact with the skin? [CAS 7440-02-0]	Yes
Is nickel (Ni) and its compounds used in surface parts likely to be in contact with the skin on the charger (including cords) or accessories? [CAS 7440-02-0]	Yes
Volume of the sellers' packaging/gift box (w x l x h), in cm ³ ?	2382.01
Volume of the mobile phone or receiver, in cm ³ ?	46.01
Is paper present in the packaging and/or the documentation (including user manual, leaflet, other information or services)?	Yes
What is the share of recycled or FSC or PEFC of paper, in %?	0
Is cardboard present in the packaging and/or the documentation (including seller's packaging, gift box, internal wedges or other)?	Yes
What is the share of recycled or FSC or PEFC of cardboard used, in %?	0
Are the printing inks used on all printed materials from non-petroleum based sources?	No
When not enforced by applicable regulation (e.g. safety legal regulation), does this device come without a physical manual (either paper or on a CD)?	No
Does this mobile phone replace the need for a digital compact camera by including a camera with a sensor with a diagonal larger than 1/2.33 inch?	No

Does this mobile phone include a real-time navigational device (e.g. satellite navigation)?	No
Does this mobile phone have a front-facing camera for videoconferencing capabilities (between two or more people)?	No

7.2 Appendix 2: Secondary data sources (models and assumptions)

7.2.1 Table 1: Semi-specific data

Device characteristics	Default value (when no answer is provided)
Screens	N/A
PCBs	N/A
Electronic components	Model based on the total silicon area (see Appendix 3)
Casings: average composition of plastic casings	(see Appendix 4)
Battery	N/A
Charger: average composition of charger	(see Appendix 4)
Rest of the device: average composition of the rest of the device	(see Appendix 4)
Packaging and documentation	Average composition of packaging and documentation (see Appendix 4)

7.2.2 Table 2: Secondary data

Formula	Data	Value	Source
Screens			
CO ₂ display	GHG emissions for the manufacturing of one cm ² of LCD screen	n/a	See EIME database version CODDE-2015-04
	GHG emissions for the manufacturing of one cm ² of touch screen	n/a	See EIME database version CODDE-2015-04
Printed circuit boards			
CO ₂ rigid (n) CO ₂ flex	GHG emissions for the manufacturing of one cm ² of printed circuit board (depending on the number of layers and the type – rigid or flex)		See EIME database version CODDE-2015-04

Electronic components			
CO ₂ components	GHG emissions for the manufacturing of components, per area of silicon in components with more than 12 connections	(see Appendix 3)	
CO ₂ casing	GHG emissions for the manufacturing of plastic casing	(see Appendix 4)	
	GHG emissions for the manufacturing of aluminium casing	(see Appendix 4)	
	GHG emissions for the manufacturing of steel casing	(see Appendix 4)	
Battery			
CO ₂ battery	GHG emissions for the manufacturing of Li-ion or Li-polymer battery	n/a	See EIME database version CODDE-2015-04
Charger			
CO ₂ charger	GHG emissions for the manufacturing of elements composing the charger	(see Appendix 4)	
Rest of the device			
CO ₂ rest	GHG emission for the manufacturing of elements composing the rest of the device	(see Appendix 4)	
Packaging and documentation			
CO ₂ pack	GHG emissions for the manufacturing of materials composing the packaging and documentation	(see Appendix 4)	
Transportation of components			
CO ₂ plane	GHG emission for plane transportation	n/a	See Ecoinvent and DEAM
CO ₂ truck	GHG emissions for truck transportation	n/a	Ecoinvent and DEAM
CO ₂ train	GHG emissions for train transportation	n/a	Ecoinvent and DEAM
CO ₂ ship	GHG emissions for ship transportation	n/a	Ecoinvent and DEAM
End-of-life			
CO ₂ truck	GHG emission for truck transportation	n/a	See Ecoinvent
CO ₂ sorting	GHG emissions for WEEE	n/a	See Ecoinvent

	collecting and sorting		
CO ₂ battery	GHG emissions for battery treatment	n/a	See Ecoinvent
CO ₂ mobile phone	GHG emissions for treatment in order to recover precious metals	n/a	See Ecoinvent

7.3 Appendix 3: Modelling GHG emissions for the manufacturing of electronic components, based on the silicon surface area

Research⁶ by Orange has identified chip silicon surface as the most relevant parameter to estimate the GHG emissions for the manufacturing of electronic components present in the mobile phone.

For this study 10 mobile phones were disassembled and for each one the following items were assessed:

- Total surface of silicon dies in integrated circuits. Stacked dies (e.g. in NAND memory) and wafer level chip scale package (WLCSP) were also taken into account,
- Total mass of integrated circuits. The different types of packaging (e.g. ball grid array, dual/quad flat no-lead, small outline package) were also considered thanks to specific models available in EIME's database,
- Total mass of transistors, diodes and surface mounted LEDs. The different types of packaging (e.g. small outline transistor, small outline diode) were also considered thanks to specific models available in EIME's database,
- Total mass of passive components, such as resistors, capacitors, inductors, SAW filter and crystals. The different types of technology (e.g. multilayer ceramic chip capacitors or tantalum capacitors) were also considered thanks to specific models available in EIME's database,
- Total mass of electro-mechanical components (e.g. microphone, headset jack, SIM card socket, antennas). For these items materials declarations sheets (MDS) were used in order to create models, which combine materials (e.g. polyamide, liquid crystal polymer, stainless steel) and manufacturing processes (injection moulding, deep drawing, extrusion).
- Total mass of soldering paste. All the soldering dots (for wave soldering) and pads (for reflow soldering) were counted and sorted according to their size (e.g. 0201, 0402, 0603 for SMD soldering pads). Documentation⁷ from electronic components manufacturers were used to assess the quantity of solder paste per pad. The total mass of soldering paste was

⁶ Life cycle assessment of mobile phones electronic boards – Orange – 2010 and 2015 (VAIJA) - contact for further information: samuli.vaija@orange.com

⁷ For example : Freescale Semiconductor - Application Note - Wafer Level Chip Scale Package (WLCSP) - 2009

then assessed by multiplying the number of dots/pads by the quantity of solder paste per dot/pad. Both wave and reflow solder paste were considered as SAC (tin-silver-copper) type,

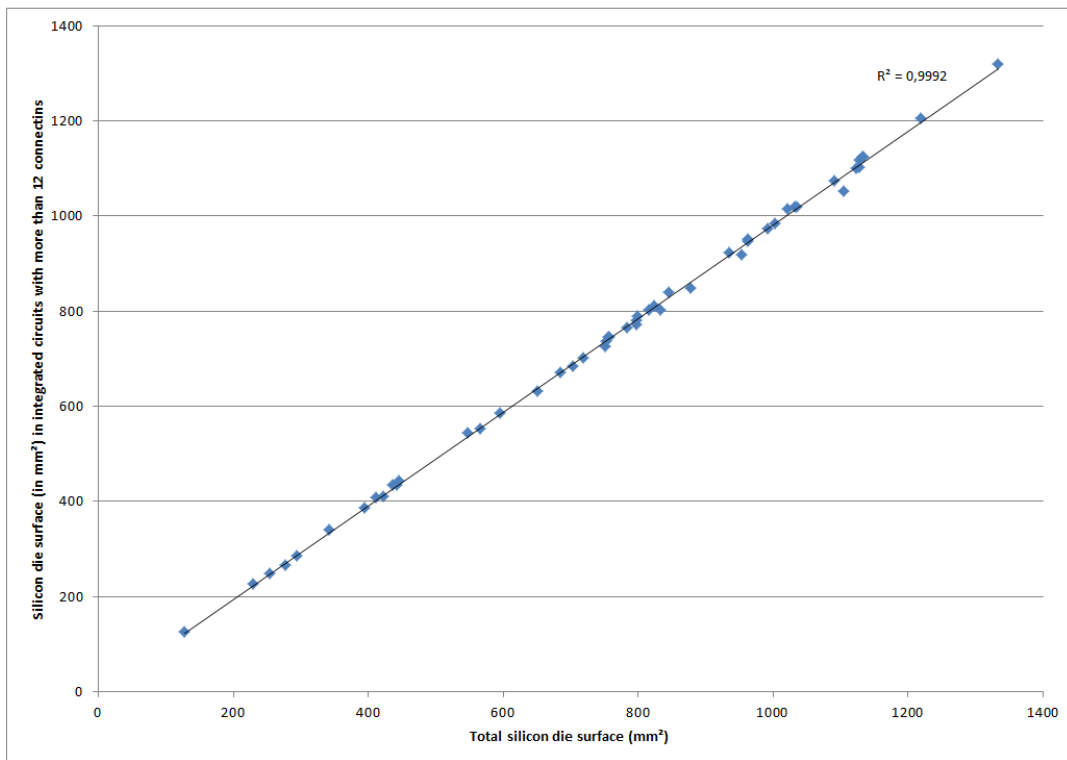
- Total area of surface plating and surface finish on printed circuit boards, such as electroless nickel immersion gold.

All this data was then inputted in EIME LCA software (Version 4 – database Version 11.0). PEP ecopassport® - PCR 2.1 method was used to obtain environmental impact results for climate change / global warming potential (noted GWP), raw material depletion, water depletion, primary energy depletion and ozone depletion potential.

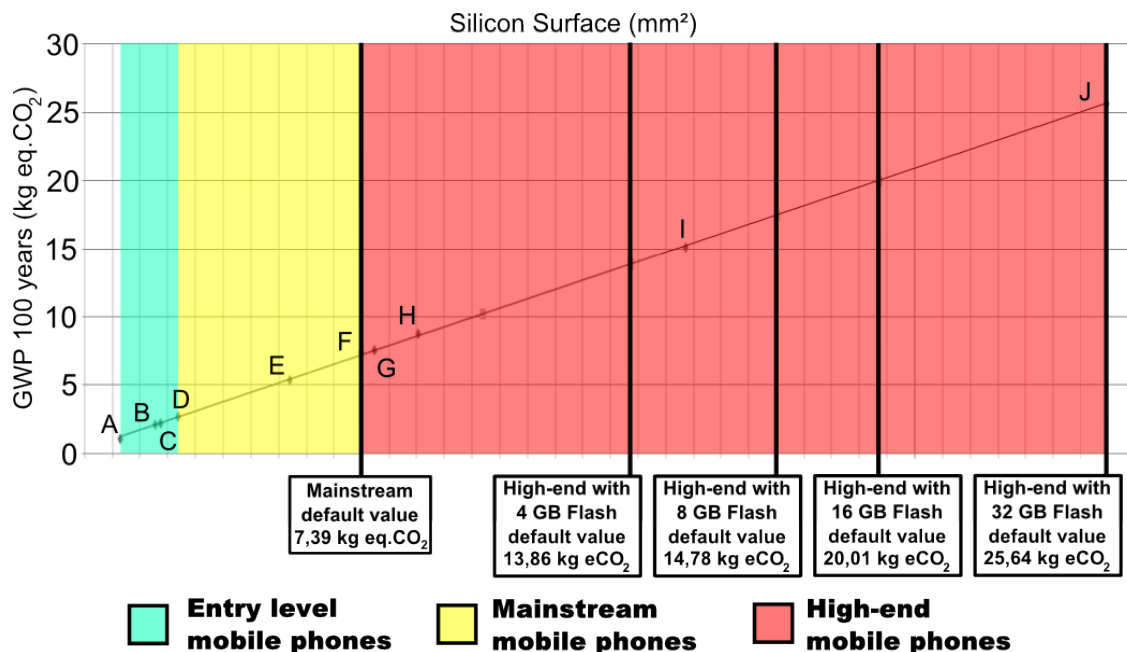
The environmental impact results (e.g. kg eq. CO₂ for GWP for each mobile phone) and key parameters, such as total silicon die surface, total integrated circuits mass or total integrated circuits packaging surface, were then inputted in statistical analysis software (Statgraphics® Centurion – Version 16.1.05).

For GWP the total silicon die surface in integrated circuits was determined to be the best approximation factor.

In order to simplify the process for mobile phone manufacturers, the silicon die surface distribution in different integrated circuits was also assessed. This extra study was carried out on 50 mobiles phones (total silicon die surface: 128.19 – 1333.09 mm²) and showed that the integrated circuits with more than 12 connections contain more than 95 % of the total silicon die surface (min: 95.02 %; mean 98.04 %; max 99.37%). The result for the 50 mobile phones is displayed in the figure below:



Once the “integrated circuit with more than 12 pins” simplification was done, the results were inputted in Statgraphics® Centurion once again. The following figure shows the linear changes for GWP with silicon surface:



For this linear regression the coefficient of determination (R^2) is equal to 0.9991, which is a very good result. Further statistical tests were also carried out with Statgraphics® Centurion, such as *Fisher–Snedecor* test (p -value = 0.9951) or *Durbin–Watson* statistic (d -value = 1.57618), in order to be sure there were no statistical issues, such as autocorrelation.

The 2010 study linear regression formula is displayed below:

$$CO_{2components} (S_{Si}) = 0.0137 \times S_{Si} + 0.3368$$

Where:

$CO_{2components}$: GHG emissions for the manufacturing of electronic components (kg CO₂ eq.)

S_{Si} : Silicon area in components with more than 12 connections (mm²)

In 2015 this method was updated to consider two key parameters:

- **Geographical area of manufacturing for silicon dies.** In 2010 the only wafer model available in the EIME database was “*Wafer, from silicon; before dies slicing; at plant; FR*”. Therefore, the model considered French electricity mix was used to manufacture the silicon dies, which is a major issue because of the very low carbon footprint of electricity in France (149g CO₂ eq./kWh according to the ELCD “Electricity Mix; AC; consumption mix, at consumer; 230V; FR” model), whereas GHG electricity emissions in China are 1111g CO₂ eq./kWh (according to Life Cycle Inventories of Electricity Mixes and Grid – Version 1.3 - René Itten, Rolf Frischknecht, Matthias Stucki – 2014). In the current EIME database (CODDE-2015-04) three wafer models are available (France – FR; China - CN and Europe - RER). This modification has to be applied directly to the 2010 linear regression formula.
- **Die size shrinking thanks to technological evolution.** In the 2010 model eight dies of 4GB were required for a 32GB NAND integrated circuit (total silicon surface = 1353.92 mm²), whereas in 2014 it only required four dies of 8GB (total silicon surface = 450.45 mm²). This size regression has to be applied to penalty values given when the manufacturer is not able to answer to the “silicon dies surface” question.

For the geographical area correction, data was gathered from several sources⁸. The result of this distribution is displayed in the table below (columns “Country or geographical area” and “Production”):

Country or geographical area	Production	Model picked in EIME
KOREA	20.61%	RER
TAIWAN	20.53%	50% RER + 50% CN
CHINA	8.95%	CN
SINGAPORE & MALAYSIA	9.51%	50% RER + 50% CN

⁸ Measuring Globalization: Better Trade Statistics for Better Policy, Volume 1 - Fig 5.8 : World Semiconductor Wafer production capacity by country 2000-2013
IC Insights - Global Wafer capacity - 12/2014
IC Insights - Global Wafer capacity - 12/2013

JAPAN	18.88%	RER
NORTH AMERICA	14.32%	RER
EUROPE	7.19%	RER

As there are only three wafer manufacturing models in EIME (i.e. France – FR; China - CN and Europe - RER), a certain number of countries/geographical areas had to be linked to one model or a mix of two models. Indeed, it is not possible to change directly the electricity mix in EIME models, as it possible with Ecoinvent models. The link country $\leftrightarrow$ EIME model was made according to the GHG emissions of electricity mixes.

The result is an average “world” wafer manufacturing environmental impact for GHG emissions. The result of a GWP assessment with the ILCD recommended indicators set (using IPCC-2007 – 100 years model) is 2.28E-02 kg eq. CO₂ / mm². This result is very close to the figure provided by AMD⁹ for its laptop APU “Kaveri” (A10-7350B) and Carrizo (A12-8800B also known as FX PRO-8800B) models (see table below, page eight of the AMD report).

Description	Kaveri (KV) Kg CO ₂ -e/die	Carrizo (CZ) Kg CO ₂ -e/die	Percent (%) Change from KV to CZ
Total wafer fabrication emissions [includes direct, indirect and upstream emissions]	5.86	5.15	-12.0

The A10-7350B is designed on a 245 mm² die, therefore the GWP result is 2.39E-02 kg eq. CO₂ / mm². For FX PRO-8800B the die surface is 244.62 mm², hence a GWP result of 2.10E-02 kg eq. CO₂ / mm².

With this wafer environmental impact update the new linear regression formula is:

$$CO_{2\text{components}}(S_{Si}) = 0.0202 \times S_{Si} + 0.142$$

Where:

CO₂components: GHG emissions for the manufacturing of electronic components (kg CO₂ eq.)

S_{Si}: Silicon area in components with more than 12 connections (mm²)

For the die size shrinking, an extensive study was carried out on 121 mobile phones (2014 and 2015 devices): 41 high-end smartphones with $\geq$ 16GB of NAND memory; 66 mid-tier smartphones with 1, 2, 4 or 8GB of NAND memory; 12 low-tier smartphones with 256 or 512 MB of NAND memory and 14 feature

⁹ Comparative Carbon Footprint Assessment of the Manufacturing and Use Phases of Two Generations of AMD Accelerated Processing Units – AMD – 2015 (available on : <http://www.amd.com/Documents/carbon-footprint-study.pdf>)

phones with 8, 16, 64 or 128 MB of NAND memory (NB: for 8/16 MB models the Serial Flash Memory was considered as a proxy for NAND)

As the aim was to set a default value for the largest surface per type of components (e.g. 32GB NAND integrated circuit), the highest value per category was selected. The table below displays the penalty silicon die area, in mm², per category:

Device	Penalty value for Si area (mm ²)	Explanation	Category
Devices with NAND capacity ≤ 128 MB	112,92	Maximum NAND capacity for a feature phone	Feature phone
Devices with NAND capacity ≤ 512 MB	276,50	Maximum NAND capacity for an entry level smartphone	Entry level smartphone
Devices with NAND capacity ≤ 4 GB	431,13	One category with Si for NAND according to NAND capacity (4 or 8 GB) and maximum area for Si without NAND (~340,39 mm ²)	Mid-range smartphone
Devices with NAND capacity = 8 GB	508,05		
Devices with NAND capacity ≤ 16 GB	1105,54	One category with Si for NAND according to NAND capacity (16, 32 or 64 GB) and maximum area for Si without NAND (~835,05 mm ²)	High-end smartphone
Devices with NAND capacity ≤ 32 GB	1429,39		
Devices with NAND capacity ≤ 64 GB	1586,15		

For example, if the manufacturer doesn't answer the "silicon dies area" question (6.4.3 Electronic components manufacturing emissions) and selects 32GB for NAND capacity, the GWP impact for electronic components will be:

$$CO_{2components} (S_{Si}) = 0.0202 \times 1429.39 + 0.142 = 29,02 \text{ kg eq. CO}_2$$

When no answer is provided to both silicon area and flash memory capacity, the maximum possible value for silicon die area is used (i.e. 2001 mm² - see 7.1.1 Table 1: Default values). The value would therefore be a GWP impact of 40.54 kg eq. CO₂. This high value is used for two reasons: first the NAND capacity is information that is easily obtainable. Therefore, there is a low likelihood there being a lack of data for this question. Furthermore, this value is a proxy for 128 GB mobile phone models, which are now available on the market, but for which there is not enough data yet to assess the silicon die area in the NAND integrated circuit.

7.4 Appendix 4: Modelling the charger, casings, rest of the device and packaging

7.4.1 **Modelling the charger**

GHG emissions for the manufacturing of the charger are calculated based on its weight.

The "reference" charger used to model this impact is a 58.1g charger with the following composition:

Sub-system two	Sub-system three	Sub-system four	Qty	PIN or no. of connections	EIME module	Ref.
Charger PCB	Circuit PCB	PCB CEM1 2-Layers -		-	PWB CEM1 2-Layers -	CODDE-0252
	Passive	Capacitor magnetic resistor and diode	32	64	Surface mounted device, RoHS (SMD)	CODDE-0068
	Passive	Capacitor magnetic resistor and diode	14	38	SMD	CODDE-0068
	Passive	Chemical capacitor	4	8	Capacitor (Ceramics, RoHS)	CODDE-0065
	Transformer		1	6	Transformer (standard for PWB)	ECO-129
	Reflow soldering SnAgCu		-	52	PWB (soldering, wave SnAgCu)	CODDE-0032
	Wave soldering SnAgCu		-	64	PWB (soldering, reflow SnAgCu)	CODDE-0030
Connector			1	-	Connectors for PWB	CODDE-0021
Plastic	Poly-carbonate		1	-	PC (poly-carbonate)	CODDE-0096
	ABS		1	-	ABS	CODDE-0093
Cable			1	-	Cable (telephone)	ECO-177
Plug			1	-	Plug	ECO-140

NB: Subsystem one is the phone charger.

It is assumed that the electronics of the charger are similar for every device, and that the changes in weight are due to changes in plastics weight. The calculation is made as follows:

$$CO_{2\text{charger}} (m) = 0,647 \times 78\% + 0,647 \times 12\% \times (m-35,6/22,5)$$

7.4.2 Modelling the casing

a) Plastic casing

It is assumed that plastic casings are composed of ABS (80%) and PC (20%). The following table presents the secondary data used for the model:

Data	Source	Year
ABS (acrylonitrile butadiene styrene)	LCA Plastique Europe	2005
PC (polycarbonate)	EIME database - Developer: CODDE - Primary sources: Industrial data from two manufacturing sites in Asia	2005
Chemicals (TPP (triphenyl phosphate), C ₁₈ H ₁₅ O ₄ P)	CRC Handbook of Lubrication and Tribology, M. P. Marino, vol 3	1994
Painting (solvent-based paint)	European Ecolabel for Paint production	1997
Moulding by injection (of thermoplastic)	CODDE/Plastics Europe	1997

The emission factor for the manufacturing of plastic casings is 10.49 g CO₂ eq. per gram.

b) Aluminium casing

It is assumed that aluminium used in casings is 51% recycled. The following table presents the secondary data used for the model.

Data	Source	Year
Aluminium (Al, 51% Recycled)	CODDE study based on EAA report	2005
Non-ferrous metals (deep drawing, Al)	ECODIS inventory by PE international	1999
Non-ferrous metals (rolled sheet production, Al)	CODDE Study - based on Ecoinvent data	2005

The emission factor for the manufacturing of aluminium casings is 7.91 g CO₂ eq. per gram.

c) Steel casing

The following table presents the secondary data used for the steel casings model:

Data	Source	Year
Steel (stainless)	Ecobilan Engineering judgement - BUWAL 98	1996
Non-ferrous metals (deep drawing, Steel)	ECODIS inventory by PE international	1999

Non-ferrous metals (rolled sheet production, Al)	CODDE Study - based on Ecoinvent data	2005
--	---------------------------------------	------

7.4.3 Modelling the rest of the device

Device components that are not modelled elsewhere are accounted for in the “rest of the device”. The emission factor is 0.046 g CO₂ eq. per gram of device, with the following secondary data used:

Data	Source	Year
Steel (stainless)	Ecobilan Engineering judgement- BUWAL 98 (secondary steel)- ETH 96 (chromium)	1996
Ferrous metals (bending, steel)	ECODIS inventory by PE international	1999
Steel (electro galvanised)	IISI (International Iron and Steel Institute) 2002. http://www.worldsteel.org/	1999
Gummy membrane (for keyboard)	Ecobilan study	1996
PP (polypropylene, moulded by injection)	Boustead; http://lca.plasticseurope.org	2005
PC (polycarbonate, moulded by injection)	Boustead; http://lca.plasticseurope.org	2005
PMMA (polymethylmethacrylate, sheet)	Boustead; http://lca.plasticseurope.org	2005
PU (polyurethane, rigid foam)	Boustead; http://lca.plasticseurope.org	2005
All materials (painting, powder-based paint)	Ecobilan study	1997

7.4.4 Modelling packaging and documentation

It is assumed that packaging and documentation are composed of a fixed part (paper and PE) and a variable part (cardboard). The following secondary data is used:

Data	Source	Year
PE (low density, LDPE, film)	Boustead; http://lca.plasticseurope.org	2005
Paper (recycled, without deinking)	BUWAL, 1996 for models of cardboard production	1996
Cardboard (96% recycled, grey board)	BUWAL, 1996 for models of cardboard production	1996

The Forum for the Future is a non-profit company limited by guarantee and registered in England and Wales.

London

Overseas House
19-23 Ironmonger Row
London
EC1V 3QN
UK

Company No. 2959712
VAT Reg. No. GB 162347319
Charity No. 1040519

New York

33 Nassau Avenue
2nd Floor
Brooklyn, NY
11222
USA

Forum US is a fiscally-sponsored
project of Tides Center, a 501(c)(3)
non-profit organization and the
nation's largest fiscal sponsor.



www.forumforthefuture.org

